CINCHONA PLANTER'S
MANUAL.

Quinine

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THE

CINCHONA PLANTER'S MANUAL,

BY

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PREFACE.

In the compilation of the following pages on cinchona cultivation, I am indebted to many for much kind assistance. The classification of such members of the cinchona genus as are of interest to us, with an enumeration of the characteristics of each, by Dr. Henry Trimen, of the Government Botanical Gardens, Peradeniya, is of great value. To Messrs. A. M. & J. Ferguson, and to all those that kindly responded to the "cinchona circular" our thanks are due.

Much valuable information is here embodied from the works of Dr. King, Dr. Bidie, and the late Mr. MacIvor; and from the India and Java Government Reports.

INTRODUCTION.

The history of the introduction of cinchona cultivation into the British and Dutch Colonies cannot fail to be interesting to those engaged in the undertaking, and I will therefore commence with a brief sketch of the subject.

The first practical step towards the introduction of cinchona cultivation to the East appears to have been taken by the Dutch Government in 1853, who despatched M. Hasskarl of the Botanical Garden of Buitenzorg in Java to Peru, for the purpose of collecting plants and seeds. Unfortunately this gentleman appears to have been misled by a native collector, and instead of collecting the Calisaya he was in search of, he obtained a species, Pahudiana, which after years of cultivation was found to be worthless and was abandoned. In 1865, Ledger, with the assistance of a bark collector, Manuel, to whom the chief credit of the transaction appears to be due, obtained the seeds of the valuable variety of Calisaya which has since borne his name. This seed was offered to the Dutch Government who purchased a large portion, the balance was purchased by Mr. Money and sown in nurseries on the Nilgiris and in British Sikkim. The produce of this seed, together with repeated supplies of seed and plants from India and Ceylon, has formed the groundwork of the very successful cultivation of cinchona in Java. The first introduction into India was under the auspices of Mr. Markham in 1860, who undertook himself to collect seeds of Calisaya in the forests of Bolivia and Southern Peru. He arranged that Mr. Pritchett should collect seeds of the grey barks from the forests of Huanuco and Huamalies in Central Peru, and that Dr. Spruce and Mr. Cross should collect seed of the red bark trees from the slopes of Chimborazo in Ecuador. Mr. Markham after encountering many difficulties succeeded in obtaining

plants of Calisaya and a few Ovata and Micrantha. Unfortunately all of these died, previous to or after their reception at Ootacamund, which had been chosen as the site for the experiment. The Calisayas were found to inhabit a belt of forest from 4,600 to 5,400 feet above the sea, and Mr. Markham's observations shewed a mean temperature of $69\frac{5}{6}°$ Fahr. the maximum being 75° and the minimum 56°. His description of the vegetation and soil is as follows:—"This region is covered with few exceptions from the banks of the river to the summits of the mountain peaks, by dense tropical forest. The formation is everywhere, as I have before said, an unfossiliferous, micaceous, slightly ferruginous, metamorphic clay-slate, with veins of quartz, and the streams all contain more or less gold-dust. When exposed to the weather this clay-slate quickly turns to a sticky yellow mud, and lower down it is very brittle, and easily breaks off in thin layers. The soil formed by the disintegration of the rock, mixed with decayed vegetable matter, is a heavy yellowish brown loam, but there is very little of it on the rocky sides of the ravine, and no depth of soil except in the few level spaces and gentle slopes near the banks of the river." The tree Calisayas are from 30 to 60 feet high, having great girth; the shrubby variety runs from $6\frac{1}{2}$ to 10 feet in height.

Mr. Pritchett's grey barks all perished en route, but the seeds he had collected germinated freely. Micrantha and Peruviana are described as large trees often 70 feet in height, and growing at an elevation of 4,000 to 5,000 feet, whilst Nitida grows at from 6,000 to 7,000 feet, and is a smaller tree.

Messrs. Spruce and Cross were very successful in obtaining, and transporting to India both seeds and cuttings of C. Succirubra. Dr. Spruce describes the red bark forests as nearly exhausted. The tree in its natural habitat is a very handsome one and attains a height of 50 feet. The elevation at which it grows is from 2,450 to about 5,000 feet. The mean temperature at 6-30 p. m. is $67\frac{3}{4}°$ Fahr., the highest observed being $80\frac{1}{2}°$, and the lowest 57°.

In 1861, Mr. Cross returned to South America to obtain seeds of the crown bark trees from the forests near Loxa. These barks are interesting as having been the first introduced into Europe, and from them the genus was founded by Linnæus. Mr. Cross obtained

abundance of seeds of Chahuarguera and Crispa, which arrived safely in India.

These forests appear to be nearly exhausted, and it was with great difficulty that Mr. Cross was able to find mature trees. He describes the soil of the region as decomposed micaceous schist and gneiss, the trees growing mostly in the alluvial deposits in ravines. The climate is moist. The temperature ranges from 34° to 74° Fahr, seldom falls below 40°, and but rarely rises above 65°. The third variety of officinalis on the Nilgiris is Uritusinga, the "original loxa bark" introduced by Mr. J. E. Howard in 1862. This tree is found growing at Uritusinga at elevations of 6,000 to 8,000 feet. It is now almost extinct.

The last species introduced to India was that yielding the "Carthagena barks" of commerce (Lancifolia and Pitayensis). In 1868 Mr. Cross collected a large quantity of the seed of this species which arrived safely in India, and some plants, which were sent first to Kew, and thence to India. He found these trees growing at elevations of 7,300 to 9,800 feet, on slopes, the surface soil of which was nearly pure vegetable mould but very mealy and dry. The subsoil he found to be a yellow porous clay in general loose and friable. He describes the climate for Pitayo bark as being exactly the same as that for crown bark. To Dr. Thwaites is due the credit of having introduced cinchona cultivation in Ceylon. He obtained a portion of Mr. Markham's consignment of seed in 1861, and with it formed the plantation at Hakgala. To quote from Messrs. Fergusons' Ceylon Directory, "For several years very little was heard about our plants, and certainly no one anticipated the development of a great planting as well as commercial success, and the cultivation was confined to the Peradeniya and Hakgala Gardens. Indeed, after the fitness of the Ceylon climate and soil for the growth of the plant was fully established, and the success in India and Java became the subject of general congratulation, it took a considerable time to convince Ceylon planters that the cultivation of cinchona was worthy of attention as a commercial speculation. Dr. Thwaites had to ask coffee planters as a favour to give a trial to the plant on their estates, and considerable numbers were for several years given away from Hakgala without charge in order to induce cultivation.

This was the case between 1862 and 1867, when a demand first sprung up for plants, but it was even then very limited and desultory. The first private experiment of any consequence was undertaken in Hewaheta by Messrs. Keir Dundas & Co. with a quarter of a million of officinalis plants from Hakgala gardens in 1868-9." Since then, and especially in the last two years, the enterprise has developed enormously, so that in the latest edition of the same work it is estimated that 33,500 acres are at present under cinchona cultivation. As will be shewn presently, the cultivation of cinchona, more than that of any other product, requires certain essential conditions of soil and climate to be successful, and hence the greatest amount of financial success should be obtained by those who enter on the undertaking with a thorough knowledge of the subject. We might well fear that this enormous extent of country would lead to a considerable glut in the market for bark, but it is certain that but a small proportion of the trees planted out will ever reach a marketable age, and herein lies our safeguard against the overwhelming supplies which are anticipated by some. Be the evil what it may—that it lies directly in the soil, and in particular conditions of soil not difficult to determine, there is little doubt—it is certain that the proportion of failures amongst cinchonas of all ages is so large as to be quite unparallelled in any other enterprise.

In considering the future, it is necessary to separate the trees yielding quinine, of which C. officinalis is the commonest type, from those yielding a large percentage of total alkaloids, as C. succirubra. Probably not 30 per cent of the total area of cinchona is under the former species (though it is difficult to say with any degree of certainty, and we can only make a rough guess) and it is almost an impossibility to obtain forest land suitable for its cultivation, through the reservation by Government of all land over 5,000 feet altitude. Hence we are justified in feeling confident of continuing to obtain good prices for the quinine-yielding barks, always provided that the relative value of the alkaloids and their preparations remains as at present. To predict as to the future course of events would be rash, but we may be sure that it will be only after a hard and prolonged struggle that the interests of the manufacturers will be set aside, and so far, there are no signs of the approach of this eventuality.

As to the red bark, it has been pointed out to us by Dr. Trimen that the bark is in itself a valuable drug, largely prescribed, and that Professor Flückiger has suggested its being fixed on as the official form of cinchona bark in the new German Pharmacopœia. We all know well its value as a source of quinetum, of a febrifuge which can be cheaply made and sold, and which ought to create an almost unlimited demand, and hence we are not over confident in looking for a ready sale at remunerative prices for the red bark which Ceylon will produce in the future.

The rivalry of cultivators in South America itself has been brought forward as a point worth consideration, and, no doubt, were there an adequate labour supply, and ready means of transport, they would prove powerful competitors; as it is, however, there can be no question that with the great advantages we possess, India and Ceylon will be able to produce the bark at much lower rates than Bolivian planters.

PART I.

PHYSIOLOGY OF PLANTS.

Before entering on the more immediate subject of this work, I have decided to give a short sketch of the structural and physiological history of plant life. In agriculture of all kinds a little knowledge of this subject is necessary, if the pursuit is to be followed intelligently; whilst for the culture of cinchona especially, when the valuable portion of the crop is stored out of sight amongst the tissues of the tree, and can only be obtained by robbing it of an essential portion of its structure, a knowledge of the organs of the tree with their functions is essential.

Chemical Composition.

It is unnecessary for me to enter into the subject of the chemical composition of plants at any length. Every one knows that vegetable substances consist of organic and inorganic matter, as they are generally, though somewhat erroneously, called; the former consisting chiefly of carbon, oxygen, hydrogen, and nitrogen, with small quantities of sulphur and phosphorus; the latter constituting the ash or non-volatile matter, and consisting of a number of metallic and non-metallic elements.

Proximate principles.

The elements composing the organic part of plants are grouped together to form various compounds known as proximate principles, which include water, wood fibre, the sugars and gums, and certain vegetable acids, fats, and oils, all of which consist almost entirely of carbon, hydrogen, and oxygen, in various proportions; they also include the *albuminoids*, which differ from the other principles by the addition of nitrogen, and small quantities of sulphur and phosphorus; and the *alkaloids*, which all consist of carbon, hydrogen, oxygen, and nitrogen alone. The latter derive their name from their likeness to the alkalies, and occur in various poisonous and medicinal plants, of which they usually form the active principle. The best known of these are *nicotine*, the poisonous principle in the tobacco-plant; *caffeine*, the bitter principle in coffee and tea; *Theobromine*, from the cacao bean resembling caffeine in its composition and qualities; and lastly *quinine*, with the other alkaloids that accompany it. The inorganic portions, or ash of the plant, consisting of a number of elementary substances in various combinations, are found in all portions of the plant; the

sap, and the tissues of plants of a high order; and in the cells of mould, yeast, and other low organizations.

I will now describe the structure of all vegetable matter, then give an account of the organs of the plant, dividing them into two classes, the organs of nutrition, and those of reproduction, and finally trace the changes undergone by a plant during its growth, and the means by which it is built up from the elements I have just noticed.

Structure of plants.

All organized matter originates in the form of *vesicles* or *cells*, which, multiplied and modified in shape and appearance, form the ground work of all plants and animals. The lowest types of vegetable life consist of one or more cells of simple structure similar to each other in nature, whilst the more highly organized plants consist of numerous cells of various forms. These cells consist of an outer membranous covering, lined with a semi-fluid substance of mucilaginous consistance, which is designated the *protoplasm*, or formative layer, and filled with a transparent liquid or sap. There is also to be seen in the interior of the cell a round body called the *nucleus*, by the agency of which cell multiplication takes place. This nucleus divides into two parts; the protoplasm then contracts, and enfolds the two halves of the nucleus at the point of division, thus separating them, and enclosing each within a cell of its own. In some cases numerous nuclei appear within the parent cell, surround themselves with a protoplasm and membrane, and become independent on the death or absorption of the former. The dimensions of vegetable cells are very various; the lemon and orange are instances of large cells, those which compose the spores of fungi being very minute.

All vegetable tissues consist of a number of individual cells, more or less closely attached by their outer surfaces, and with intercellular spaces between them in places, which are mostly filled with air.

Vegetable Tissues.

There are four principal varieties of vegetable tissue, cellular tissue, woody tissue, bast tissue, and vascular tissue.

Cellular tissue is a simple aggregation of globular or polyhedral cells, whose walls are in close adhesion; it is the only tissue in the simpler forms of plants, and the soft parts of the higher forms are chiefly composed of it.

Woody tissue consists of cells that are many times as long as they are broad, that taper to a point at the

ends; they cohere firmly together at their sides, and their ends overlap each other, thus forming the tough fibres of wood.

Bast tissue is made up of cells similar to those of woody tissue, but is much more flexible. The bast or inner portion of the bark consists of this tissue.

Vascular tissue is a term applied to the unbranched tubes and ducts which are found in the higher order of plants interpenetrating the cellular tissue; their formation takes place by a simple alteration of the latter. A longitudinal series of cells represents a tube, but for the partitions at the end of each cell which obstruct the bore. By the removal of these obstructions a tube is developed.

The Root.

Of the organs of nutrition, the first to be noticed is the root. The growth of roots occurs mostly by lengthening, and slightly by thickening, the growth in length being confined to a space of about one-sixth of an inch from the top. By this peculiarity the root is enabled to penetrate into the minutest pores of the soil. All plants whose embryos have two seed leaves or cotyledons, and whose stems increase externally by addition of new rings of growth,—the dicotyledonous plants or *exogens*,—are furnished with a tap-root, which penetrates vertically into the ground, and from which lateral roots proceed. The monocotyledonous plants or *endogens*, whose embryos have only one cotyledon, and whose stems do not increase by external addition, give off a number of roots from their bases and have no tap-roots. The chief offices of the root are to fix and sustain the plant in the soil, and to absorb nutriment from the soil for the support of the whole plant. With the object of sustaining the plant in the soil, tap-roots are much more effectual than side-roots starting direct from the base of the stem. The absorption of nourishment from the soil takes place along the whole length of the rootlets, which branch from the lateral roots; the latter becoming corky, and losing their absorptive power, in a short time after their development. The rootlets are covered with an enormous number of root hairs, which come into close contact with the particles of the soil, and adhere to them with great tenacity; they also show great absorbent force, and imbibe water from the soil with sufficient force to send it into the stem, and to exert a constant pressure on all parts of the plant. Such of the food of the plant as is derived from the soil enters in a state of solution, and is absorbed with the water taken up by the rootlets.

As regards the internal structure of the root, it is the same as that of the stem, which I will now describe.

The rudimentary stem, as found in the seed or in the newly formed portions of the growing plants, consists of cellular tissue, *i. e.*, of an aggregate of rounded and cohering cells, which rapidly multiply during the vigorous growth of the plant. This substance is soon penetrated by vascular tissue, consisting of ducts or tubes, resulting from the obliteration of the horizontal partitions of cell tissue; and by wood cells, longer than they are wide, and thickened by depositions of various substances on their walls. These ducts and wood cells are found in close connection, arranged as bundles, and disposed lengthwise in the stem and branches.

In endogenous plants, a class which embraces the palms, Indian corn, sugarcane, wheat, barley, &c., and all the grasses, the stem is enlarged by the formation of woody bundles dispersed amongst the older ones, and not arranged in concentric layers. In exogenous plants, a class which includes most forest trees, the bean, pea, potato, &c., as the stem enlarges, new rings of fibres are formed, but always outside the older ones. This formation takes place just inside the bark or rind, the bundles of ducts and fibres being disposed in a circle round the stem, and closing up into a ring or zone of wood, which encloses unaltered cell tissue—the *pith*.

The *rind*, which at first consists of a mere epidermis overlying soft cellular tissue, becomes penetrated with cells of unusual length and tenacity, which are termed bast cells ; these, on the development of the tree, give the bark its peculiar toughness, and cause it to come off the stem in strips.

Between the fully formed wood, and the mature bark, occurs the growing part of the exogenous stem. This is the *cambium*, or formative tissue, from which on the inner side wood fibres, on the outer bast fibres, rapidly develop. In temperate climates the spring time, in tropical regions the wet season, is the time when the new cells of the cambial region are delicate and easily broken ; and at this time the bark can be separated from the wood without difficulty. In the autumn or dry season these cells become thickened and indurated, become in fact full grown bast and wood cells, and to peel off the bark smoothly is impossible. The bark may be considered to consist of four layers, first the cambium already described; second, the liber, consisting

chiefly of bast fibres; third, the cellular tissue; and fourth, the corky epidermis which lies outside. It is the third layer, consisting of cellular tissue, which contains the alkaloids of cinchona bark, and constitutes the greatest portion of its bulk.

From the cambium to the centre of the tree run the *medullary rays*, or pith rays, which are portions of the first formed cell tissue, which were interposed between the young and originally unshed wood fibres; which are in fact the cells which have not formed themselves into vascular tissue, by the process previously described. Besides these, the wood is hardened by the tissues of lateral branches, which are thus connected with the centre of the stem.

Certain plants are also supplied with what are called *milk ducts*, which yield the gum-resins, and other substances of which caoutchouc is an instance.

In temperate climates, perennial exogenous stems consist of a series of concentric rings corresponding to the number of years of growth; in the tropics, where trees keep their leaves all the year round, the correspondence is not so decided. As I have said before, all the processes connected with cell multiplication and enlargement, with the growth of the tree in fact, are carried on in the cambium layer; the processes are not confined to this however, but extend to a considerable depth in the wood, where the transmission of the sap, and the deposition of the matter on the interior of the wood-cells is carried on. The outer layers of wood are thus called *sap-wood*, and when cut are liable to decay unless seasoned. The inner layers or *heart-wood* are much denser and more durable, the cells having become filled up by the deposition of matter until they are impassable to sap.

Leaves consist of a thin membrane of cell tissue, directly connected with the cellular tissue of the bark, arranged upon a frame-work of ducts and fibres continuous with those of the inner bark and wood. The whole surface of the leaf on both sides is covered with an epidermis consisting of thick walled cells, which are for the most part devoid of liquid contents, except when very young; below the upper epidermis there often occur one or more layers of oblong cells, arranged endwise with reference to the plane of the leaf; below these, down to the lower epidermis, the cells are irregular and loosely disposed, with numerous and large interspaces filled with air. The structure of the veins is the same as Leaves.

that of the vascular bundles of the stem, of which they are a continuation. On the lower sides of the leaf are the breathing pores or *stomata*, connected with the intercellular spaces in the interior of the leaf. They are actual openings in the skin of the leaf, which become enlarged in moist air, and nearly or entirely close in dry air.

The upper epidermis of some leaves, particularly in hot climates, is impregnated with wax, making it impenetrable to moisture, as in the case of coffee. A considerable loss of water goes on from the leaves of growing plants exposed to the air in the form of invisible vapour. This loss is greatest when the atmosphere is dry, and least in damp weather. Through the stomata of the leaves, air and other gaseous bodies have access to the whole interior of the tree, by means of the ducts which ramify throughout the veins of the leaf, and branch from the vascular bundles of the stem.

We now come to the organs of reproduction which comprise the flower, fruit, and seed.

The flower. The flower is a short branch, having at its end certain organs which, though usually having little resemblance to leaves, may be considered as leaves more or less modified in form, colour, and office. The flower is generally provided with four sets of organs, the *calyx* or outermost envelope, which generally protects the bud before it has opened; the *corolla*, which is one or several series of leaves called petals, and which often has marked peculiarities of form and colour. These organs are envelopes to protect the essential organs of the flower, the *stamens* and *pistil*.

The stamens are generally slender and thread-like, and are terminated by an oblong sac, the *anther*, which, when ripe, discharges a fine yellow or brown dust, the *pollen*.

The pistil generally occupies the centre of the flower, the summit being termed the *stigma*, and the base the *ovaries* or seed vessels.

For the purpose of fructification, the pollen from the stamens must fall upon or be carried by wind, insects, or other agencies, to the tip of the pistil. Thus situated, each pollen grain sends out a slender tube, which penetrates the interior of the pistil until it enters the ovary, and comes in contact with the ovule or rudimentary seed. This contact established, the ovule is fertilized, and begins to grow. Some flowers are deficient in one of the essential organs, which is borne by another flower on the same or another tree.

In the vegetable kingdom, fertilization of the flower of one plant by the pollen of another results in a *hybrid*, but the limits within which this is possible appear to be very narrow. A plant of one family cannot be fertilized by a plant of another, but within the same genus there is every gradation. Some hybrids are absolutely sterile, whilst others are completely fertile.

Individuals are classed under the same *species*, when the difference between them is no greater than experience has shewn between plants raised from seed of the same parent.

Individuals of the same species differ. When these differences assume a comparative permanence and fixity, a *variety* is established.

Varieties often cannot be reproduced by seed, but are continued in the possession of their peculiarities by *cuttings*, *layers*, and *grafts*.

Species which resemble each other in most important points of structure, are associated by botanists in the same group, called a *genus* ; *families* or *orders* are groups of genera that agree in certain particulars. *Classes* are groups of orders, and *series* are groups of classes.

The fruit. The fruit comprises the seed vessel and the seed, and differs greatly in various plants.

Life of the plant. Having now described the most important parts of the plant and their structure, we will briefly consider the life of the plant, and the part they play in its growth.

Germination. The first action of the seed when placed in the ground is to absorb moisture, and in consequence to swell and become soft. The integuments then burst, and first the radical, and afterwards the plumule, appear. At first the young plant grows entirely at the expense of the seed, and it is not till the roots are into the soil, and able to derive their own nourishment from it, that the seedling has commenced an independent existence.

Action of roots. The roots of the plants, which are in intimate connection with the soil, absorb most of the water that fills the active cells of the plant, and with it such salts as the water holds in solution ; this water contains much carbonic dioxide, and has in consequence a powerful solvent action on the mineral constituents of plant food.

Action of leaves. The leaves absorb carbonic dioxide from the air, which is decomposed, the carbon remaining, and the oxygen being rejected. This action, however, only takes place under the influence of the sun's light. The fluid absorbed by

the roots, and containing the inorganic plant food, rises up the stem, where it becomes mixed with organic matter, to the leaves. Here it undergoes important changes, and descends to supply material in the growth of new wood.

Motion of the juices.

The motion of the fluids in plants takes place partly by direct passage along the ducts in the youngest tissues, and partly by a slow exudation from cell to cell; its cause being the absorption of materials for the formation of new tissues, the loss by evaporation through the leaves, and the loss by extravasation through the vessels compressed in the oscillations produced by wind. The supply of water to the foliage of a plant from the roots continues when the cellular tissues intervening are interrupted, but is at once checked by severing the vascular bundles. The motion of the nutritive matter in the former being one of slow diffusion through the walls of the cells, which goes on in all directions.

Nearly all the organic substances in the plant are formed in the leaves, and descend chiefly through the cambium, which is in direct communication with their tissues, to supply nourishment to the stem and roots. This movement, though taking place more readily in the vascular tissue, is not confined to it; the cellular tissue also admitting of the transport of nutritive matter downwards.

Girdling a tree is not fatal if done in the spring time in temperate climates, provided the young cells which form externally are protected from dryness, and other destructive influences. An artificial covering to take the place of the bark, keeping the exposed wood moist and away from air, saves the tree until the wound heals over. If the freshly exposed wood be wiped with a cloth, so that the young cells of the cambial layer, (which contain nuclei, and are capable of multiplying) are removed, no growth can occur.

To sum up:—The nutrient substances in the plant are not confined to any path, and may move in any direction. The fact that they chiefly follow certain channels, and move in certain directions, depends on the arrangement and structure of the tissues, the sources of nourishment, the seat of growth, and other action.

The motion of the juices is due to the porosity of all vegetable tissues, and to several principles, the first of which is adhesive or *capillary attraction*; this is the force that causes liquids to rise in fine tubes, and is due to the fact that there generally is attraction between

the molecules of the liquid and the solid; the commonest example being that of the motion of the oil in the wick of a lamp, which rises to fill the pores of the wick, as fast as they are emptied by the combustion of the oil at the top.

A second principle is that of *liquid diffusion.* A vial full of coloured sugar and water or brine, lowered into a jar of water, will discharge its contents into the latter, receiving water in return, and this will go on until the whole of the liquid is uniform in composition; that is, until the whole of the sugar or salt is diffused through the water equally.

By this principle, continual movement is the result of causes which tend to alter the composition of a solution or of a mixture of liquids.

A third principle is that of *osmose* or *membrane diffusion.* When two liquids are separated by a porous diaphragm, the phenomena of diffusion are complicated with those of capillarity and of chemical affinity. The adhesive force which the diaphragm exerts on the liquid molecules is added to the mere diffusive tendency, and the movements may suffer remarkable modifications. If we separate pure water, and a solution of common salt, by a fixed membrane, the diffusion takes place through it in the same way as though it were absent. But, the water moving faster than the salt, the volume of the brine increases, and that of the water diminishes, a change of level in the liquids thus occurring.

The application of these principles to the movements of liquids in plants is obvious; the cells and the tissues of cells furnish precisely the conditions for the manifestation of motion by the imbibition of liquids, and by simple diffusion as well as by osmose.

Late researches have shewn that the motion of the plant from wind is also one of the agencies which assist in maintaining equilibrium in the fluids of plants.

Reproduction.

Reproduction is essentially an exhaustive process, and does not commence till the plant is provided with a store of accumulated food sufficient to sustain it. The flowers of some plants are produced from terminal buds, others from lateral buds resting on the seasoned wood of the previous year, in which nutritive matter is accumulated. In the sago palm and sugarcane for instance, advantage is taken of their store of amylaceous and saccharine matter, which accumulates and attains its maximum just before the first appearance of the flower buds.

The preceding description, which will be found to contain many facts interesting in connection with cinchona, is compiled from a most lucid and valuable work, " How crops grow," the English edition of which is by Messrs. Church and Dyer, the original and less known work beingby Professor Johnson, of Yale College, U. S. A.

PART II.

CHAPTER I.

THE ALKALOIDS.

The most important constituents of cinchona bark are the alkaloids enumerated in the following tables:—

Alkaloids.		*Chemical composition.*
Cinchonine...	...	... $C_{20}\ H_{24}\ N_2\ O$
Cinchonidine	...	... do.
Quinine ...	...	... $C_{20}\ H_{24}\ N_2O_2$
Quinidine ...	...	... do.
Quinamine	...	... $C_{20}\ H_{26}\ N_2\ O_2$

The order of their formation has been determined by Mr. Broughton, and is as follows:—The alkaloid first formed in the bark of all the species except the grey barks, is uncrystallizable quinine or quinamine. This alkaloid, quickly in *C. officinalis*, and less quickly in *C. succirubra*, changes into pure crystallizable quinine. Again, after a time, with much rapidity in *C. succirubra*, and with greater slowness in *C. officinalis*, this quinine changes into cinchonidine. Finally, after a considerable lapse of time, the cinchonidine changes into cinchonine, the last form in which the alkaloid as such exists. The composition of each of these alkaloids is so nearly identical, that their actual conversion in the tissues of the living bark is certain. Warmth of climate accelerates these changes, and hence barks grown at low elevations contain less quinine, and more cinchonine, than those at high elevations. It also follows that the quicker a tree grows, the more quinine, and the less cinchonidine, will be found in the bark; the formation of quinine being more rapid than its conversion into the inferior alkaloids. Hence the accelerated growth at low elevations in part compensates for the detractive influences of the climate. This conversion is probably due to the action of light on the bark. Formation of alkaloids.

The order of their present value is as follows:—First quinine, by far the most valuable; then cinchonidine; quinidine and cinchonine in the order named. Relative values.

The leaves of cinchona contain but a minute quantity of alkaloid, a small proportion only of which is quinine. I quote as follows from Dr. King's book:—"The bitter taste of the leaves is largely due to the presence Presence in various parts of the tree.

of quinovine. The flowers of the cinchonas contain no alkaloid, but a considerable amount of quinovine; while ripening fruit contains but the faintest trace of alkaloid, and ripe seed none whatever. The act of flowering does not appear to have any direct influence on the amount of alkaloid in the bark. As regards the wood of cinchona trees, Mr. Broughton found that dry red bark wood contains 0·08 to 0·11 per cent of alkaloid, of which 0·004 is quinine; and that pale or crown bark wood yields 0·0101 per cent, with 0·004 of quinine. The chemical form or state of combination in which the alkaloids occur in living bark is a point of much importance. Mr. Broughton's researches led him to believe that in red bark four-fifths of the total amount of alkaloids exist combined with quino-tannic acid in a *solid* state within the tissues, and most probably exclusively within the cellular tissue. The alkaloids appear not to be very active vital constituents, but rather to be stores, of which only a small portion at the most shares in the changes incident to growth. The remaining fifth of the total alkaloid is in solution in the juice of the bark." With regard to the disposition of the alkaloids in the bark, Mr Broughton found the cellular portion to be far richer than the liber in quinine, and, to a less degree, in yield of total alkaloids. Thus, in one experiment with red bark, the liber was found to contain total alkaloids 6·85, of which 0·85 was quinine, whilst the cellular portion of the bark gave 8·20 per cent, and 3·25 per cent, respectively.

The value of the bark increases from the branches downwards; these being poorest in alkaloids, whilst the root is richest.

Value as febrifuges.

Of the alkaloids the most valuable is quinine, the salt of which, sulphate of quinine, is now most generally employed in place of the former decoctions and tinctures of bark. The popularity of this alkaloid has caused the others to fall into unmerited neglect, but recent trials given to them in the Indian Presidences have established their value as febrifuges. For the manufacture of decoctions, tinctures, &c., the red bark, being rich in its yield of total alkaloids, has always been esteemed; but the demand being limited, there is no probability of its price for these purposes only being kept up; on the other hand the demand for quinine is increasing, and with little probability of the market being flooded.

Report of Commission.

For many years it was suspected that the other alkaloids were nearly if not quite as valuable as quinine, and a commission was appointed in 1867 to test the

efficacy of pure sulphates of each of the four alkaloids quinine, quinidine, cinchonidine, and cinchonine. The resulting report states that "in a large proportion of cases in which they were tried chemically pure, sulphate of quinine, and sulphates of quinidine and cinchonidine, appeared to indicate nearly equal febrifuge power, and in equal circumstances, their use produced almost the same physiological results. . . . . The result confirms the general opinion expressed by the commission last year, and likewise conclusively establishes beyond doubt that ordinary sulphate of quinine, chemically pure sulphate of quinine, and sulphate of quinidine possess equal febrifuge power; that sulphate of cinchonidine is only slightly less efficacious; and that sulphate of cinchonine, though considerably inferior to the other alkaloids, is notwithstanding a valuable remedial agent in fever."

Broughton's "Amorphous Quinine."

The object of the Indian Government in their cinchona ventures being chiefly the production of an efficient febrifuge, which should he procurable at a low price in every Indian village, Mr. Markham suggested that instead of sending their bark to England to be sold, and purchasing thence the alkaloids in their purer forms, a febrifuge should be prepared from it on the plantations, which should contain the alkaloids in a rough form, and be saleable at a cheap rate. Accordingly, in 1866, Mr. Broughton was appointed as Government Quinologist with this view. As the result of his experiments, Mr. Broughton issued a preparation called "amorphous quinine," consisting of the total alkaloids of cinchona bark in an amorphous or non-crystalline form, and largely mixed with the colouring matter and resin so abundant in red bark.

After the production of some 600 lbs. of amorphous alkaloids, a commission reported that the mixture cost far more than ordinary commercial quinine, and the factory was closed.

Sikkim febrifuge.

A year later (1874), Mr. Wood started a factory in Sikkim with the same object, and produced a febrifuge having the following composition:—

Crystallizable quinine ...	... 15·5	parts.
Amorphous do. ...	... 17·0	"
Cinchonine	... 33·5	"
Cinchonidine	... 29·0	"
Colouring matter, &c. ...	... 5·0	"
	100·0	

The Government of India having consented to look, not at the price their bark would fetch in the markets of the world, but at the actual cost of production, the febrifuge can be sold to the public at about Rs. 20 per lb.

The result of recent comparisons between this febrifuge and the sulphates of cinchonine and cinchonidine, has been to place the three in the order mentioned for value.

These results were unexpected, as previously cinchonidine has invariably in every respect taken a higher place than cinchonine ; they cannot therefore be taken as conclusive. The objection to the Sikkim febrifuge is the uncertainty of its composition, which renders its falsification easy. It also causes sensations of nausea, and is somewhat unpopular on that account. Notwithstanding this however, it has made its way with the public and the faculty, until its manufacture and annual sale have touched 10,000 lbs. The result of this is that the Sikkim plantations have been not only an indirect benefit to the country, but a great financial success to the Indian Government.

Local preparation of pure alkaloids.

Mr. Gammie, of Rungbee, is now engaged it appears in endeavouring to separate the alkaloids in their pure form ; whether this will be a success or not is as yet doubtful, excessive cost having hitherto rendered such endeavours fruitless. He has succeeded in extracting pure sulphate of quinine from *calisaya* bark, and from the red bark he has obtained the same alkaloid, affected by a small proportion of cinchonine only. The process also is said to be so cheap, that, rating the value of the bark at the cost of its production, as in the case of the mixed febrifuge, sulphate of quinine could, in fact, be sold at about the same low price. The great difficulty is the thorough exhaustion of every trace of alkaloid from the bark. The great manufacturers have appliances, and probably secret processes, which give enormous advantages. In Java, as in Madras, attempts to extract the alkaloids from the bark have been given up as failures, as was previously the case in South America. All the more credit will therefore be due to Mr. Gammie if he succeeds in his endeavour, where success cannot but be considered exceedingly doubtful. It seems probable that local febrifuges will never be able to compete with the cheaper crystallized alkaloids as prepared in England, which are nearly if not quite as effective, nd are of fixed composition. Thus, whilst the

Sikkim febrifuge was being sold for Rs. 20 per lb., sulphate of cinchonine could be bought for Rs. 5, and sulphate of cinchonidine for Rs. 17·50 in England.

For the English market the quinine yielding barks are required, and there is but little fear of the supply exceeding the demand ; whilst if the local preparation of febrifuges from the red barks is a success, there will be less fear of the supply of the latter flooding the market.

For the sake of the masses of India, who as yet cannot be supplied with the febrifuges they so greatly need, in sufficient abundance, and at a sufficiently low rate, we must wish every success to the praiseworthy efforts of those who are endeavouring to bring them within their reach.

Crystallization of the Alkaloids.

Some confusion has arisen of late with regard to the meaning of the various terms "crystallized sulphate," "crystallizable quinine," "pure quinine," &c. As has been said before, the alkaloid first formed in the bark is uncrystallizable quinine, which changes into pure crystallizable quinine during the growth of the tree, or under the influence of certain artificially produced conditions. Thus, whereas the red bark yields a large proportion of amorphous or uncrystallizable alkaloid in its natural state, the mossing and renewing process changes their character, and to a great extent renders them crystallizable. Of all the alkaloids, quinine, it appears, is alone capable of taking up water of crystallization, thus forming crystallized quinine, without the addition of sulphuric or any other acid. The crystallizable alkaloids during their conversion into sulphates under the hand of the manufacturer increase considerably in bulk, and the following communication by Mr. A. C. Dixon puts the matter very clearly.

"Quinine is represented by the chemical formula $C\,H_{24}N\,O_2$, that is a molecule (or smallest portion of matter which can exist in a *free* or physical state) is built up of 20 atoms of Carbon, 24 of Hydrogen, 2 of Nitrogen, and 2 of Oxygen, (an atom is the smallest portion of matter that can exist in a *combined* or chemical state). Now the atomic weight of carbon is 12, Hydrogen (the unit of weight) being 1, Nitrogen 14, and Oxygen 16 : therefore the total weight of a molecule of quinine is

$$20 \times 12 + 24 \times 1 + 2 \times 14 + 2 \times 16$$
$$= 240 + 24 + 28 + 32$$
$$= 324$$

" The ordinary Sulphate of quinine has a composition represented by this formula

$$(C_{20}H_{24}N_2O_2)_2,H_2SO_4,7H_2O.$$

H_2 SO_4 denotes Sulphuric acid; the atomic weight of Sulphur is 32, therefore the weight of a molecule of this acid = 98; H_2 O denotes water, the molecule weighing 18, and Sulphate of quinine in crystallizing takes up seven such molecules which we term water of crystallization.

" For brevity denoting Quinine by the symbol Q we have

$$Q_2 + H_2SO_4 + 7H_2O = Q_2,H_2SO_4,7H_2O.$$

Quinine + Sulphuric acid + water = sulphate of Quinine, that is by weight

$$648 + 98 + 126 = 872,$$

which tells us that by taking 648 parts by weight (any unit we please, ounces, pounds, &c.) we manufacture theoretically 872 parts by weight of crystallizable Sulphate of Quinine, so that 648 lbs. Quinine would yield 872 lbs. Sulphate, therefore 3·06 Quinine would yield 4·12 of Sulphate.

" The statement of Howard is 3·25 Sulphate of Quinine = 2·50 Crystallizable Quinine: this is not exactly corect but an approximation. Mr. Howard's proportion is probably the practical yield, allowance being made for loss in manufacture. The theoretical yield is 648 Quinine gives 872 Sulphate, that is about 9 to 12, while Mr. Howard's proportion is 10 to 13."

CHAPTER II.

SPECIES, VARIETIES, &C.

In classifying the cinchonas, the first difficulty we encounter arises from their extraordinary habit of sporting or hybridizing, consider it as which we will. This peculiarity is most marked in the finest species, the *calisaya* especially, and the *officinalis* in a somewhat lesser degree.

Uncertainty of seed propagation.

The chief objection generally given to the method of propagating from seed, is the liability shewn by the finer species to sport; for from seed from a single tree, plants will appear of numerous shades of leaf, and variety of foliage. Experience has shewn that the value of some of these varieties is more than that of the parent tree, and though others may be less so, the average value will be about the same. It is generally supposed on the other hand, that with cuttings you are certain of

a plant exactly similar to the original tree. This however has been proved not to be invariably the case; cuttings from the same plant frequently producing trees with considerable diversity of foliage, such diversity, however, not going beyond the bounds within which it would be possible for the parent tree itself to vary. No doubt the chances of perpetuating valuable species are immensely greater in the case of cuttings, and this method must be resorted to in such cases; but, considering the slowness of the process, and the considerable amount of uncertainty that attends it, propagation by seeds will always be the more popular method.

Variation.

Mr. Broughton in writing to Mr. Howard says, "You will I am sure forgive my expressing the opinion that many kinds, which you seem disposed to allot separate names to, are not specifically distinct. It is true, the specimens you receive shew great divergence in appearance and structure, but were you to see the plantations, and observe how (among the crown barks for instance), every kind passes by imperceptible gradations in the individuals into another, I think that you would allow that these distinctions are not absolute. A tree which for six months has the habit of your *uritusinga*, will all of a sudden begin to have shorter leaf-stalks and leathery leaves, and begin to look like *crispa*. The typical individuals of each variety are very distinct, but there are trees which would, I think, trouble even you to assign them their places."

This diversity of appearance amongst cinchona trees raised from the same crop of seed is frequently attributed to hybridization. The fact of trees from cuttings shewing a tendency to sport should shew the fallacy of the idea in some cases. The *officinalis* trees referred to in the previous extract were all raised from two parents only, which plants there is every reason to believe were identical, yet their progeny, not from seed, but from cuttings, shew all the varieties known as *officinalis*, *condaminea*, *uritusinga*, *crispa*, &c. The tendency to vary is so strong that even a twig in a tree shews foliage different from the parent types. There are instances in Ceylon, too, of clearings, planted from seed which could not have been the result of cross fertilization under any conceivable circumstances, and which contain trees exhibiting every variety of form and foliage.

This tendency to variation, and to the production of new forms, if properly taken advantage of, is one of the most hopeful features of the cinchona enterprise. In

Java, the selection of the most valuable forms during a few years has resulted in an increase of value of fully 50 per cent in the *Ledgerianas*, compared to their value when first introduced.

On the subject of cinchona hybrids, Dr. Bidie writes as follows :—" Owing to the dimorphic condition of their flowers, and from other unknown causes, the plants of the cinchona family are particularly liable to cross breeding. In fact, if different species are grown contiguously, it is impossible to prevent crossing. This facility for hybridizing may therefore, in the hands of a skilled manipulator, be turned to great advantage in the way of producing valuable hybrids. Speaking of cross breeding Lindley says :—' Hybridizing is a game of chance played between man and plants, and what increases the charm of the game is, that although the end of it may be doubtful, yet a good player can judge of the issue with tolerable confidence, and that skill and judgment have in this case all their customary value.' Some of the hybrids produced on the Nilgiris have proved worthless, and others very valuable."

The following extracts from Mr. McIvor's notes shew the origin of the hybrid *C. pubescens*, which I shall presently describe. " So soon as our plants flowered, or early in the spring of 1865, I made a vigorous attempt to attain this object. The result was that in 1866 a number of hybrid seedlings were produced. Among these, distinct varieties—possessing remarkable vigour of growth—were selected, and the weakly-growing sorts destroyed. The selected varieties were planted here and there in every soil, exposure, and elevation available. Under all these conditions, our new seedlings maintained that remarkable vigour of growth which at first distinguished them. This raised my hopes still higher. A fresh batch of promising hybrids was produced and selected with great care, when suddenly all hope of improvement was consigned to oblivion, by the announcement of the quinologist " that these hybrids combine the bad qualities of both their parents." I took no official action in this matter as it was not within my province to decide. I admit that privately I may have received this announcement ungraciously. It was opposed to the experience of ages ; it cut away what I believed to be a well grounded hope. I suggested the possibility of error, and the desirableness of further investigation, but the statement with which I was met shook confidence in my own opinion, and for nearly ten months caused the prosecution of

further investigations to cease. It is well understood that under certain conditions hybrids may and frequently do degenerate, but this defect is corrected by "selection."

"Circumstances, however, soon arose, which clearly indicated that under certain conditions, these seedlings produced a bark of great value. Subsequent investigation shewed that the same variety maintained nearly equal value in its bark, in all the conditions under which the plants were placed. Evidence was clear also that in these vigorous growing hybrids, we had secured in a marked degree the good qualities of both parents."

Again :—"As early as 1865 this plant, (*C. Angustifolia*), was applied to the only profitable use that could be assigned to it, namely, to hybridize strong and vigorous species, so as to secure in some of their progeny vigorous growth, strong constitution, and high quality of bark. All these qualities have already been obtained in a marked degree in *C. pubescens*, Howard."

The theory of hybridity, though doubtless a factor which has to be taken into account, has unquestionably been carried too far. It is an easy enough way out of a difficulty, (and it has been practised with many genera besides Cinchona), when one has before one an intermediate-looking plant, to call it a hybrid, selecting as its assumed parents two forms with which it appears to have points in common; but it is obvious that much more than that is required to establish the fact. The most elaborate carrying out of the hybridity theory is shewn in the recent work of Herr O. Kuntze, who investigated all the forms growing in the Java and Sikkim plantations, and has classified the whole as hybrids arising from four fundamental species; he abandons all the old names as superfluous, but if only as a matter of convenience, most persons will prefer "*C. officinalis*" to his "*C. Pavoniani—Weddelliana.*" Careful experiments, or the accurate record of them, on this subject, are still urgently needed. The flowers of cinchona are dimorphic, and it is clear that where as in Ceylon several kinds are grown in proximity, carriage of pollen from one to another may very readily occur, with a very probable result of fertilization. At present, however, very few well authenticated cases of undoubted hybridization have been recorded.

"W.F.L.," in a communication to the *Ceylon Observer*, in which he strongly upholds the theory of somewhat extensive hybridization, supports it with the statement that at the intermediate zones, where climates of inferior suitability to the growth of the various species are met with, we come

across a larger number of hybrid forms, which are better suited to the climate they grow in than the parent trees from which they trace their origin. The statement is a very interesting one, and perhaps points to the self-establishment of a kind of plant suited to the climate, but the whole subject is as yet obscure, and requires a series of very careful and elaborate experiments before any thing in connection with it can be said to be proved.

Classification. I am indebted for the following remarks on classification, and short descriptive notes of the various forms, to Dr. Henry Trimen of Peradeniya.

The genus cinchona presents us with a very well marked and striking instance of a clearly defined natural group, in which the individuals composing it, instead of as usual being with more or less facility thrown into different sets marked out by clear distinctive characters, (and thus forming the "species" of the naturalist), offer themselves as a crowd of forms closely connected in different directions, but shewing only trifling modifications of structure, of a sort usually regarded as of but little systematic value. Such genera are not very uncommon, and the botanist of Europe is but too familiar with cases in *Salix* (willows), *Rubus* (blackberries), and *Rosa* (wild roses).

This state of things is natural, and has not arisen under cultivation. In *cinchona*, the great majority of the described forms have been found in the Andes themselves, where the genus has a range of over 2,000 miles from North to South, and at altitudes from 2,600—11,000 feet, but chiefly between 5,000 and 8,000 feet. It would appear that every district of this extensive area has its own peculiar cinchonas, and very few species are known to range widely through it; none to occur throughout. A very similar statement might be made with regard to the fruticose *Rubi* in Europe.

In attempting to deal systematically with such a set of plants, the botanist finds himself placed between the alternatives either of giving names and specific rank to slight forms which it is next to impossible to describe so as to ensure their recognition by others, or, if he throw together many such forms, owing to the difficulty in drawing any lines of demarkation, of being driven to carry his combination far beyond what he intended.

In *Cinchona* both processes have been pushed to extremes. In consequence of undoubted differences in the qualities and even the structure and appearance of the barks, by which they are without much difficulty recog-

nised in the market in a dried state, almost every sort having had a distinct name, it was thought that the trees affording them should also be botanically distinct; and nearly every slight and variable form received the dignity of a specific name and standing (or even two or more names). A great part of the labour of modern writers has been the endeavour to bring these, most of which should never have seen the light, into order and system. Long ago Mutis proposed to reduce all that he knew to two species, and more recently it has been suggested that a single specific type would contain the whole. Herr Kuntze could see only four species in the plantations of India and Java; on the other hand Triana—who is followed by Bentham and J. D. Hooker—admits 36 species; whilst Weddell has 34 species and 18 sub-species, and there is little doubt that if the genus ever had the misfortune to be taken in hand by one of our "splitting" botanists, the numbers would be greatly exceeded; considerably over 100 "species" have indeed been published.

Since the extensive cultivation of Peruvian barks in the Old World, a new systematic difficulty has arisen. As is to be expected under such circumstances, where multitudes of individuals are grown in close proximity, many varieties have been noted, and some selected and propagated. Of these, some may be new forms, or at least previously unobserved, others are more or less similar to ones already noticed in South America. An effort to correlate these (which have not unfrequently received plantation names more or less correct) with the latter, has therefore to be made.

In the following classified list it is attempted—following pretty closely the course adopted by the late M. Weddell, which is also supported by Mr. Howard—to steer a middle course. In his last paper on the subject M. Weddell proposed five divisions, ("stirpes" he calls them), under which he grouped his 52 species and sub-species, frequently again combining some of them into sub-divisions ("rami"). It has not been thought necessary to include the less known species, but the twelve leading ones here described probably contain all the forms grown in Ceylon and India, besides of course many others. It would be perhaps preferable to have reduced the real species to pretty nearly the five types or sections here given, the "species" here enumerated being rather to be considered as fairly permanent "races." Still whatever rank we may accord them, some distinguishing name must be given. The scale or grade of the "sec-

tions" in the following list is framed in the hope and expection that, as Mr. Howard believes, the sporting and variability from seed, great as it undoubtedly is, will be found not to transgress their limits.

The bark-characteristics are not given. A good scheme of classification founded on these would be perhaps possible, and *taken in conjunction with other characters* would certainly be useful in a group where at present it is not too much to say that we have not a single good specific distinction.

SECTION I. OFFICINALIS.

C. Officinalis. I. *C. officinalis*, Linn. (Crown bark). A tree reaching 35 feet or more in height, with a naked stem, or two to four stems, and an ovoid rather tapering leafy head, with spreading or even drooping branches; or a mere bush, four feet to eight feet high. Leaves four to five inches long, varying from broadly oval or even sub-rotund to lanceolate, acute at both ends, usually smooth on both sides, shining full green above, paler beneath, with glandular hairy depressions in the angles of the lateral veins (scrobicules). Capsule oblong-ovate, about ¾ inch long, and about twice as long as broad. Flowers rose coloured. Calyx-teeth triangular acuminate (having elongated points). Flower buds not inflated at the end.

The *varieties* (for they scarcely amount to permanent races) of C. officinalis are numerous, and very ill-defined. The principal which have received names are:—

Uritusinga, Pav. (original Loxa bark), characterised by its broad large leaves, wavy or undulated at the margin, and very prominent leaf-veins: a large forest tree. This is the original type of the species. *C. academica*, Guib.

Condaminea, Howard, scarcely differs from the last in its smaller and non-wavy leaves, with less strongly marked veins, and a more lax inflorescence. *C. Chaharguera*, Pav. is the same as this. A smaller tree than the preceding and affords the "Rusty crown bark."

Bonplandiana, Howard, very near the last, but the leaves apparently narrower and the bark different. Mr. Howard includes here three minor forms under the names *colorata*, *lutea*, and *angustifolia*. The latter is the accidental variety obtained by Broughton, and called by him "lanceolata," or "mirabilis," which was found to be so rich in alkaloids. It is a delicate tree, with small peach-like leaves.

Crispa, Taf. The thick texture of the narrow leaves, and the very strongly marked and conspicuous scrobicules, are the characteristics of this form, which is generally little more than a shrub in habit. Its name is derived from the short fracture of the bark.

Confusion in Nomenclature.

There has been much confusion about the nomenclature of this species here and in India, arising from its extreme variability, the very slight differences between many of the forms which have been thought to be permanent varieties, and the fact that various authorities have spoken of the same plant under a different name. Mr. C. R. Markham, in consequence of the confusion in the nomenclature of the species of cinchona from the forests of Loxa, the three principal varieties of which had been classed previously as *1. Uritusinga ; 2. Ghaharguera ; 3. crispa*, proposed the following classification instead:—*1. Condaminea , 2. Bonplandiana ; 3. crispa.* These names appear to have been permanently adopted in the Government reports, which speak of *C. officinalis*, var. *Condaminea* (Uritusinga Howard, original Loxa bark), var. *Bonplandiana* (Chaharguera, select Crown bark) ; and var. *crispa* (fine Crown bark). That this nomenclature has not been generally adopted is evident from the fact that Mr. Howard continues to apply the term *Uritusinga* to the tree which he introduced, whilst a gentleman, who studied the matter in India, says that the terms there used for two common forms of Crown bark are *Uritusinga* and *Condaminea.* He also informs us that the proportion of the larger forms is greater at the Neddiwettum than at the Dodabetta plantation. The classification here adopted shews the distinguishing characteristics of each of the varieties in question. This matter of nomenclature is not one of extreme importance owing to the instability of the varieties in question, and the many intermediate forms to which it is difficult and undesirable to apply names, but it is essential that we should know the kind of tree from which the seed so freely introduced here from India is taken, and be able to identify those yielding the various barks of commerce. The tree, quick-growing and large-leaved, often called *Condaminea* in Ceylon may be another variety, or not improbably a permanent hybrid of *officinalis* with *succirubra.*

Pubescens, How. [not *C. pubescens*, Vahl]. This is considered by Mc'Ivor a hybrid between *succirubra* and *officinalis*. It grows very luxuriantly, with a clear stem free from lichens. Its name alludes to the hairiness of the leaf on the under sur-

face, the upper surface being smooth. The leaves are large and leathery, approaching in size to succirubra. Flowers pink, and similar to the ordinary officinalis. The young wood is rapid of growth, and it renews its bark readily. But little is known at present about this form, which to judge from some examples, said to be authentic, approaches *C. succirubra.*

C. macrocalyx. 2. *C. macrocalyx*, Pav. (Ashy Crown bark.) Leaves obovate, sub-acute at the end, thick, hairy beneath. Calyx-teeth linear-lanceolate, as long as the adherent portion of the calyx, (see Howard's figure in his "Illust. Nuev. Quinol."). This is the *C. Condaminea* var. *Candollii* of Weddell formerly. It includes *C. Palton*, Pav. *C. lucumæfolia* Pav. &c.

C. lancifolia, 3. *C. lancifolia*, Mutis. (Columbian bark). Leaves lanceolate or ovate-lanceolate, acute or attenuate at both ends, scrobiculate. Calyx-teeth short triangular, capsules lanceolate, fully three times as long as broad. Weddell formerly placed this also under C. Condaminea.

Varieties. Karsten, followed by Howard, distinguishes several of these, but their characters so far as published are not very important. They are called *vera*, *rubra*, *obtusata*, and *discolor*, names which explain themselves. The last is a broad-leaved form. Mr. Howard has also described, as var. *oblonga*, the variety affording "soft Columbian bark," or "calisaya of Santa Fé."

Section II. rugosæ

C. pitayensis. 4. C. *pitayensis.* Wedd. (Pitayo bark). Leaves very similar to those of *C. lancifolia.* Corolla hairy within. Capsule long-ovoid. One of the hardiest species. *C corymbosa*, Karst. may be referred to this as a variety.

C. pahudiana. 5. *C. pahudiana*, How. A tall tree. Leaves oval or obovate-lanceolate, with short petioles (leaf-stalks), small, thick, grey-hairy beneath, and without scrobicules. Corolla-tube five-angled with the angles channeled at the base. Capsule hairy, ribbed. Seed-wing narrow.

This is one of the four primary species of Herr Kuntze, from which all the remainder have been, according to him, derived by crossing. It is a worthless species, but formerly much grown in Java, where, though now eliminated from the plantations, it still grows in the forest where originally planted out by Haskarrl.

Section III.—Micranthæ.

6. *C. scrobiculata*, Humb. and Bonpl. (Red Cuco bark). A tree 30 to 60 feet high, with a roundish head and ascending (with upward slope) branches. Leaves oblong-lanceolate, acute at both ends, rather thick, shining above, nearly smooth and very minutely scrobiculate beneath. Capsule tapering from a wider base, scarcely twice as long as wide, bright red when ripening. Flowers small and pink. C. scrobiculata.

C. peruviana, How. (finest grey bark), and *C. nitida*, R. and P. (genuine grey bark), which afford the grey barks of Huanuco, are closely allied to this, and a similar bark is given by the next species.

7. *C. micrantha*. Ruiz. and Pav. (grey bark). A very beautiful, robust tree, ten to thirty feet in height, with spreading branches. Leaves large, seven to ten inches long, rotundate, broadly ovate or obovate, but attenuate into the petiole at the base. Petiole short in the large leaves, but longer in the smaller floral ones. Texture of leaf thinner than the last, smooth above, very finely puberulous beneath, with tufts of hair but scarcely scrobicules in the vein-angles. Flowers small, the corolla usually white, with the tube slightly contracted at the base and mouth. Capsule oblong, three or four times as long as broad. The leaves of this species are often marked by a bloom in the upper surface, and a purple colour below, which cause the tree to be mistaken for a Calisaya. C. micrantha.

Varieties. Weddell gives five varieties under the names *huanucensis*, *reicheliana*, *affinis*, *calisayoides* and *rotundifolia*, but does not afford their distinguishing marks. The var. *calisayoides* is probably to be referred to *C. Calisaya* itself and is near var. *pallida* of that species.

Section IV.—Calisayæ.

8. *C. calisaya*. Wedd. (yellow or calisaya bark). A very tall tree with a straight bare stem and leafy crown, or a shrub. Leaves oblong, ovate-oblong, or lanceolate-obovate, usually obtuse at the apex, attenuate at the base, or rarely acute at both ends (often so when young), two to seven inches long, smooth on both surfaces or pubescent beneath, with or without scrobicules, on short petioles. Capsule small ovate, flower-buds usually much enlarged at the ends. C. calisaya.

Varieties. This species is remarkable for the numerous forms under which it presents itself, which appear to be with difficulty referred to any definite or recognizable varieties. The most prominent are these, but too much value must not be attached to their characters.

Vera. Leaves ovate-oblong, obtuse, attenuate at the base, green, perfectly smooth on both sides or very slightly velvety beneath, distinctly scrobiculate. Capsule ovate, rounded at base, about ⅓-½ inch long.

Microcarpa, Wedd. Leaves oblong-ovate, or oval, obtuse, pubescent beneath, and often purplish ; few or no scrobicules. Capsules smaller.

Boliviana, Wedd. Leaves larger than the type, obovate-oblong, obtuse, membranaceous, smooth on both sides or pubescent beneath, which is more or less purplish, scrobicules absent or very rare. Capsules larger, ovate, and a little attenuate at the end.

Oblongifolia, Wedd. Leaves smaller than the type, narrowly oblong, obtuse, green on both sides, pubescent beneath, nearly devoid of scrobicules ; capsule as in the last.

Pallida, Wedd. Leaves more oval than the type, very obtuse, thinly membranaceous, full green, without scrobicules, panicle more lax, and flowers apparently smaller than in the previous varieties.

Ledgeriana, Wedd. A small tree with a pyramidal head. Leaves longer, narrowly oval-oblong or truly lanceolate (the widest part being just at the middle), obtuse when mature, quite smooth (when young often subacute and slightly hairy), often purple beneath, the veins and petioles usually tinged with red. Panicle small, flowers crowded and small, more or less drooping, yellowish white or rarely tinged slightly with pink, corolla-tube short, wide, and dilated (hence the flower-bud not inflated at the end), greenish. Capsule small and short, almost globular. Dr. King describes the 6,300 plants raised from Ledger's seed in the Java plantations, which are now thirteen years old, as rather shabby-looking trees, averaging in height 25 feet, and girthing at six feet from the ground 27 inches. They have tall stems, and rather small, lax, conical heads, the branches of which are more or less distinctly arranged in tiers. This is the most distinct of the varieties of calisaya and has perhaps claims to be considered distinct from it. When not in flower it may be generally known by the form of the leaf and the dull yellowish tinge of the whole foliage.

Josephiana, Wedd. Usually a shrub six to ten feet high with many erect branches, leaves oblong or obovate-lanceolate, very smooth, rigid, with or without scrobicules. Capsule larger than type, and often more or less attenuate above. It appears that this form is not always a mere bush, and that much of what is called in Ceylon "calisaya vera" should rather be referred to it. It also includes the "Schuhkraft" of Java; there is a sub-variety, *discolor*, with broader leaves which are pubescent and purplish beneath.

Javanica. This is characterized by broader and blunter leaves. *C. anglica*, How. is said to have resulted from crossing *C. calisaya* with *C. succirubra*, and has intermediate characters, forming a very handsome tree. *C. hasskarliana* is stated by Dr. de Vrij to be a hybrid between *C. calisaya* and *C. pahudiana*, but by Dr. Anderson between the latter and *C. officinalis*. It has the leaves very pubescent almost woolly beneath.

Section V.—Ovatæ.

9. *C. succirubra*, Pavon (red bark). A tree reaching it is said 50 to 80 feet, head rounded-pyramidal. Leaves large, rounded-ovate or ovate, obtuse, usually acute or even tapering at the base, margin wavy, bright apple green, paler beneath, becoming when withering a fine red or orange-pink, upper surface usually with fine scattered short hairs, or smooth, the veins deeply impressed, under surface with the veins, especially the midrib, very thick, prominent and pubescent, the leaf itself smooth, and forming deep concavities (convexities above) between the veins (like a cabbage-leaf), no scrobicules. C. succirubra.

This is certainly a less variable type than those above given. *C. erythroderma*, Wedd., and *C. rosulenta*, How., however appear to be marked forms, the latter perhaps worthy of a higher rank.

10. *C. ovata*, Ruiz and Pav. Leaves broadly ovate, subacute, attenuate at the base, smooth above, tomentose, pubescent beneath, panicle-cluster when in fruit—diffuse, capsule lanceolate or oblong-lanceolate. C. ovata.

There are several varieties of this tree, which presents also remarkable differences in the bark it affords.

11. *C. cordifolia*, Mutis. (Columbian bark). A medium sized tree with a lax head of spreading branches, the young branchlets with a yellow-brown pubescence. Leaves very C. cordifolia.

broadly oval, or even roundish, subacute or obtuse, rounded or slightly cordate at base, finely and densely pubescent on both surfaces when young, but nearly smooth above when full-grown, no scrobicules, petioles long, veins red. Capsule ovate oblong, wing of seed finely perforated. The hard Carthagena bark probably belongs here.

Known by its yellowish pubescence. This species has the widest range of any cinchona and there are naturally a good many forms. *C. lutea*, Pav., *C. platyphylla*, Pav., *C. subcordata*, Pav., and *C. rotundifolia*, Pav., are referable here.

C. pubescens.

12. *C. pubescens*, Vahl (Arica bark). Leaves broadly ovate, subacute attenuate at base, especially when young, membranous, smooth above, pubescent beneath, petioles short, capsule linear-lanceolate.

The most marked variety of this is *C. purpurea*, Wedd. with the leaves purplish beneath, and a very narrow pubescent capsule. *C. caloptera*, Miq., is probably a variety of *C. pubescens.*

We now come to the more practical portion of this subject, the consideration of the cultivation of the commoner species in Ceylon. For this purpose, it is more convenient to adopt a simpler classification than the preceding, and discuss, first the *yellow bark* trees, or calisayas; second the *crown bark* trees, or officinales; third the *red bark* trees, or succirubras; fourth the *grey bark* trees; ending by a consideration of a few other well-known species, with the hybrids.

The three species most commonly cultivated in Ceylon, and to which our chief attention must be directed, are the *calisaya*, *officinalis*, and *succirubra*, the order mentioned being, to speak generally, that in which they stand both for rarity and value, *calisaya* being the most and *succirubra* the least valuable of the three.

The yellow bark trees.

Of all the *calisayas*, the most valuable is that to which a Mr. Ledger has given his name. The great value of this bark does not consist merely in the amount of quinine it contains, as much as 13 per cent in some cases, but also in the fact that it is contained in an almost pure state in the outer cells of the bark; the cinchonidine, of which there is a small quantity only, existing in the inner bark or liber, next to the cambium. This tree has certain well marked characteristics (previously described), which distinguish it from the inferior varieties. Amongst these, *calisaya javanica* seems to vary greatly in results. For instance

a bark of this kind gave such a good return as 6·59, of which no less than 4·27 was quinine. But another specimen, though it shewed 6·73 total, gave only 1·77 of quinine; a third with 3·29 gave only traces of quinine. *Calisaya josephiana* (the Java *calisaya schuhkraft*, the *calisaya vera* of Hakgala) gives 6·46 total alkaloids, with quinine 0·73 and quinidine 0·38. It is most important that the distinction between *ledgeriana* and the common *calisayas* be carefully maintained: the former being of great value; the latter, in many cases apparently similar to the former in appearance, being of very inferior value. Judging from the experience of Mr. Moens, it would appear that *ledgeriana* has claims to be considered as a distinct species, for it does not appear amongst the seed from other forms, nor does it ever pass into them. There is no doubt that this fact adds greatly to its value, by lessening the risk attendant on its cultivation. It is greatly given to sporting, but always apparently within certain well defined limits. From seed supplied by Mr. Moens from some of the best *ledgerianas* in Java, the bark of which yielded nine per cent of quinine, plants have been produced scarcely two of which are alike, and some which in size and form of leaf suggest sometimes *officinalis* and sometimes *succirubra*. In young plants, largeness of leaf is rather a favourable characteristic than otherwise, as indicating luxuriance of vitality and growth; whilst, on attaining a mature age, this large foliage gives place to a growth of smaller leaves. This valuable variety, though so much given to sporting, is the kind which above all others we should endeavour to propagate on a large scale in Ceylon, as soon as we are assured that its cultivation will prove a success.

In Ceylon, the *calisayas* have in some cases shewn a spindly habit, pushing out primaries close to the ground. This is perhaps due to an unfavourable exposure at too high an elevation. Amongst others, a planter in Balangoda has three years old *ledgerianas*, which have attained a fair size for their age, the average size is reported as seven feet in height, and six inches in girth. In Maskeliya, six years old *calisaya* trees average thirteen feet in height and ten inches in girth, the largest being twenty feet high and thirteen inches in girth. In Madulsima, plants from Mr. Moens' seed have so for been most successful; two oz. of seed yielded 40,000 plants, all of which are growing well, and though only put out seven months ago, they vary in size from one foot to three feet six inches. The *calisayas* in

In Ceylon.

Pussellawa, growing at an elevation of 2,500 feet, nine years old, have yielded on analysis 5·215 per cent total alkaloids, of which 2·534 is crystallized quinine sulphate. These trees, according to Mr. Howard, though true *calisayas* are not *ledgerianas*; considering the low elevation at which they are growing, the analysis cannot but be considered most satisfactory. On the Annfield estate, Dikoya, a *calisaya* yielded the following analysis:—Quinine 3·06 (equivalent to cryst. sulpht. quinine 4·12), amorph. alk., cinchonidine, &c. 2·77. Total alkaloids 5·83. There has been considerable discussion in Ceylon as to the identity of these trees, and those on a neighbouring estate. The seed it appears came from Sikhim, but before the product of Ledger's seed was distinguished from the many inferior forms with which it had got mixed. They have been recognised by Mr. Moens as mixed *javanica*, *josephiana*, with some *hasskarliana*, and that gentleman considers that the analysis quoted must be above the average, which he places at from 1½ to 2 per cent of alkaloids. Practically it may be said that the cultivation of this fine variety (*ledgeriana*) is in its infancy in Ceylon. There are some trees at Hakgala, and a good many scattered here and there on plantations, but, outside nurseries or very young clearings there are comparatively few growing as yet. According to Mr. Moens, true *ledgerianas* rarely flower before the eighth year, and he never takes seed from those that flower at an earlier age.

To shew that in Ceylon at any rate *calisayas* arrive at maturity at an early age, we hear that a square inch of bark from a three years old tree has been found one-third heavier than the same amount from a four years old *succirubra* tree. It is also found that *calisaya* in Ceylon gives a much more mature looking bark at an early age than *succirubra*, and that, like *officinalis*, it would yield a good marketable bark at three or three and a half years of age. Not that it would be advisable to take bark from any species so soon, but under certain circumstances, this early maturity becomes of value.

In Java.

In Java, the *ledgeriana* plantation has proved one of the most wonderfully successful undertakings on record, and the history of the 14 acres of this variety, which were planted in 1866, shews a return of 10,126 florins per acre during the seven years from 1872 to 1878, or 1,448 florins per acre per annum. In spite of this enormous return the plantation shews no signs of thinness, and,

were it now up-rooted, would give a return of at least £2,000 per acre! By the method of harvesting now employed however this result will be greatly exceeded The bark of one tree in this remarkable plantation, No. 67, has been found to contain the wonderful proportion of 13 per cent of pure quinine, besides other alkaloids. Another, No. 78, has yielded a bark containing 10·5 per cent of quinine, and no other alkaloids.

On the Nilgiri hills, in the Government plantations, *ledgeriana* has been found a failure, growing but slowly, and adopting a weak spindly habit, but giving a very satisfactory analysis as follows:—Total alkaloids 5·30 per cent, consisting of quinine 3·00 (2·81 crystallized), and cinchonine and cinchonidine 2·30 (0·75 crystallized cinchonidine). Captain Cox has given us a list of analyses of the bark of trees from the same neighbourhood, almost rivalling those of Java, the best shewing 10·10 per cent of sulphate of quinine. In India.

In the Darjeeling plantations it has grown better, but strangely enough, whilst the analysis of some barks shewed them to be excellent, that of others was found inert. A small portion of Ledger's seed was sent here in exchange for *succirubra*, but the plants were not kept separate from those grown from *calisaya* seed from other sources. Lately, by analysis of the bark, and by means of observations which Dr. King made in Java, the true *ledgerianas* have been distinguished from other *calisayas*.

The following are official analyses of the barks of six different kinds of *calisayas*: whether all are from Ledger's seed or not is not stated, but, from the ages given, it is probable that Nos. 5 and 6 alone are:—

		Total alkaloid.	*cryst. quin. sulphate.*
No. 1.	Five years old, shrubby variety	1· 6	none
,, 2.	Five years old, under surface of young leaves purple	6· 1	4·53
,, 3.	Five years old, leaves with light-coloured midribs ...	5·57	4· 6
,, 4.	Five years old, leaves broader than No. 3. ...	7· 1	6·92
,, 5.	Seven years old, small green leaves	5·75	5·34
,, 6.	Seven years old, small green leaves	7· 4	6· 2

these results as a whole were considered very satisfactory, but other kinds that were examined gave very inferior results. The failures are perhaps attributable to an unfavourable climate, Dr. Bidie considering them as due to extreme elevation ; for the plant is tender, and does not stand exposure to much wind or intense cold.

The yield of bark from *calisayas* at Darjeeling seems satisfactory, four acres coppiced yielding at the rate of 1882 lbs. per acre.

Advisability of their cultivation in Ceylon.

Finally, as to the general advisability of cultivating *C. calisaya* extensively in Ceylon. It is evident from what has been said before that the cultivation of common varieties of *calisaya* is not advisable when we have *officinalis* and *succirubra.* Their value is very uncertain and compares very unfavourably with both the latter species, whilst in point of growth they are at a decided disadvantage. Mr. Roberts' Pussellawa trees would appear to be an exception to this, some of them giving a very good analysis, but it is doubtful what variety they may be referred to. Many of them having been analysed however, it would appear to be quite safe to propagate extensively by cuttings from the most valuable trees. From all we can learn it is evident that elsewhere the bark of *ledgeriana* has not given results at all approaching to those arrived at in Java ; whilst Mr. Howard, the great quinologist, does not appear to take a very sanguine view of the prospect of growing *ledgeriana* in Ceylon, as rich in quinine as those produced by Mr. Moens in Java. Mr. Howard seems to think that the rich volcanic soil of Java (corresponding to that in the native habitat of the cinchona on the Andes) has a good deal to do with the richness of the bark in alkaloids, and evidently inclines to the view that a variety of *officinalis* will be found best suited to the climate and soil of Ceylon. On the other hand Mr. Moens is confident from personal observation that we have climate and soil in the majority of our districts well suited for the cultivation of *ledgeriana.* He adds however that whereas the growth of calisaya trees here is equal to that in Java, that of *officinalis* is better. Taking into consideration the fact that in *officinalis* we have a species that suits our circumstances admirably, that in Sikhim some *ledgerianas* were found of comparatively small value, and that we are as yet uncertain whether this species will thrive and grow rapidly with us, it is unadvisable to do more

at present than cultivate it on a small scale. The scarcity of plants and seed has obliged us to do this hitherto, and probably this is not to be regretted at present. Meanwhile the more analyses, and the greater number of experiments with this species in various localities, the better. The worthlessness of several varieties should however be borne in mind, and the greatest care exercised in tracing and identifying the parent tree from which we propose to take seed. The original stock of trees from Ledger's seed are situated in Java, Darjeeling, and a few on the Nilgiris. The two former localities are the only ones from which, as far as I am aware, true *ledgeriana* seed from trees whose bark has been analysed can be obtained; and without this guarantee of the purity of the parent stock, we risk the reproduction of a variety of inferior value. Some weight is doubtless to be attached to outward appearances in estimating the value of a tree, where the examination is made by one who has thoroughly studied the subject, but careful analysis is as a rule the only sure method.

Elevation. The most suitable elevation for *calisaya* will probably be found to lie between 3,000 and 4,500 feet in most districts, and higher in the Uva districts. Mr. Moens advises from 3,600 to 5,000 feet for *ledgeriana.*

C. ignota. In the Darjeeling plantations, a new species of cinchona made its appearance, which was at first considered a hybrid, but is now known as *ignota.* The first plant of this appeared amongst a set of seedlings from seed forwarded by Dr. Thwaites from Ceylon. It grows more rapidly than *calisaya* and thrives at a higher elevation. A sample of bark from trees seven years old, growing in Rungbee, at an elevation of 3,200 feet, yielded total alkaloids 6·5, crystallized sulphate of quinine 4·10.

Crown barks. *C. officinalis* in its various forms has given the best results in Ceylon, and there can be no doubt that its cultivation is an established success. Some mossed and renewed bark has fetched 10s. 6d. per lb., whilst the current prices for ordinary quill are from 4s. to 7s. per lb. Some of this bark, from an eight years old tree on Langdale estate, grown at an elevation of 4,600 feet, yielded crystallized quinine sulphate 5·86 per cent; crystallized cinchonidine sulphate 1·13 per cent. The value being estimated at 10s. per lb. This shews that Mr. Broughton's opinion, that at elevations under 5,000 and 6,000 feet the bark is not a quinine yielder in quantity, must be modified by the experience of Ceylon. From Melton estate, at an elevatiou of 5,000 feet, an analysis

of crown bark shewed total alkaloids 3·94, of which 2·73 was crystallized quinine sulphate; this was valued at 4s. per lb. Another analysis of five and a half years old bark from the same estate shewed 2·56 crystallized quinine sulphate, and 1·79 cinchonidine, valued at 5s. 2d. per lb. There is also the well-known and oft-quoted example of the Lool Condura *officinalis* bark which was taken for *calisaya*, and paid for as such, by such authorities as Messrs. Howard and Whiffen. An analysis of five and a half years old bark from this estate is also given, shewing 4·84 per cent of crystallized quinine sulphate.

Varieties.

Like the *calisayas*, this species is much given to sporting, some trees having small peach-like leaves, and others large leaves approaching in size to those of *succirubra*. The most valuable variety is that discovered by Mr. Broughton at Dodabetta, the bark of which on analysis was found to yield the then unprecedented amount of from seven to ten per cent of crystalline quinine, the total alkaloids in the bark being more than eleven per cent. The name of this variety is *angustifolia*. It is found however that the varieties which yield the most valuable bark are far less robust in habit than the more common varieties; *angustifolia* itself being of slow growth and delicate constitution, whilst the variation in the quality of its bark is so great as to render its cultivation unsafe. An analysis of the variety *crispa*, from Hakgala, by Mr. J. E. Howard, has been published by Dr. Trimen; it shews total alkaloids 5·20 per cent, with 4·10 of quinine, equivalent to 5·45 per cent of crystallized quinine sulphate. This tree is of slow growth, but seems well suited for exposed situations. The difference in the amount of bark yielded by the small and large varieties is enormous; from two healthy trees growing side by side, the one large leaved, the other small leaved, I have obtained seven and three-quarter lbs. and one and a quarter lbs. respectively. These trees were five and a half years old, and both fair specimens of their kind. It is advisable therefore that preference be given to the large leaved robust varieties of *C. officinalis*, as not only is the larger yield of bark from such trees to be considered, but the fact that mossing and renewing, with the value of the bark increased thereby, is more practicable with them than with the small spindly trees which are generally killed by the operation. We all find most marked differences in clearings of this species between the size and vigour of the large leaved varieties and the small, and though the general rule is that the

smaller the leaves the more valuable the bark, this is more than counterbalanced by the greatly increased yield of the robust varieties. As is shewn elsewhere, the robuster the tree the more valuable is the bark, within the limits of a variety ; the dwarfed growth of certain varieties of *officinalis* is a characteristic natural to them, and consequently beyond the application of this rule.

The large-leaved form.

The one we have found most satisfactory in Ceylon is a large leaved form, frequently considered a hybrid between *officinalis* and *succirubra.* It is in reality, as far as can be judged, the true *uritusinga* of Mr. Howard, which as I have shewn before, has had the term *condaminea* applied to it in the Indian Government Reports. The following analyses by Mr. Broughton shew the values of the three principal varieties of *officinalis*, at the early age of three years and eight months :—

	Condaminea (uritusinga How.)	*Bonplandiana.*	*Crispa.*
Sulph. of quinine crystallized	1·54	1·61	0·87
,, cinchonidine ,,	1·70	1·80	1·75
Total alkaloids	4·08	3·91	3·81

The analyses of samples of bark from Morland estate in Ceylon have also been published ; the trees from which the bark was taken are designated as hybrids, but from the description it seems probable that they are the large leaved variety of *officinalis.* The best sample yielded 2·9 sulphate of quinine, and was valued at 4s. 6d. per lb. The analysis of what is called an "*officinalis hybrid*" in Pussellawa, six years old, at an elevation of 4,000 feet, shewed 8·775 of total alkaloids, of which 4·439 was crystalline sulphate of quinine. This tree is no doubt identical with what I have called the large leaved variety of *officinalis*. From Ootacamund, a gentleman gives an analysis of what he designates as "*C. robusta*," (no doubt the variety in question, as it was in answer to a request for an analysis of it), shewing total alkaloids 8 per cent, with 5 per cent quinine. Mr. Rowson, of the Government cinchona plantations, quotes the following analysis of bark from a sixteen years old tree :— Quinine 3·53 (yielding crystallized sulphate 4·75), quinidine 0·08, cinchonidine 1·33, cinchonine 0·20. From Java, the following analysis of an eight year old tree is given, quinine 1·37, cinchonidine 4·82, cinchonine 0·79, amorphous alkaloid 2·00. In the latter case the large

proportion of cinchonidine is very remarkable, and the analysis looks more like one of *succirubra* than of any variety of *officinalis.* It is probable that the tree in question is a different one to the variety we are now discussing. The very great superiority in point of yield of bark shewn by the large over the small varieties, and the very satisfactory analysis given by the former, make the advisability of cultivating them as much as possible very apparent. Unfortunately, the tendency to sporting makes it impossible to obtain a clearing consisting solely of trees of any given variety, but much can be done in this way by careful selection. If the seed be persistently taken from trees of the desired form, and propagation by cuttings be resorted to as much as possible, a measure of success is inevitable.

Yield of plantations.

Of the yield of *officinalis* plantations in Ceylon there is not much evidence. On Lool Condura, 9 lbs. dry bark have been obtained from individual eleven and a half years old trees uprooted. In Haputale, twelve years old trees have given 7½ lbs., coppiced. From four years old trees in Dimbula, 1¼ lbs. have been taken. In Nuwara Eliya, 16,000 three and half years old trees gave 5,000 lbs. bark uprooted. From a plantation of *officinalis*, five years old, I have obtained only ⅓ lb. dry bark per tree, root included, and Mr. Taylor from a six and half years old clearing 1¼ lbs. In each case the root bark formed ⅓rd of the whole. In the former case circumstances were unfavourable to the growth of the trees, but the difference between the growth of the few large leaved trees that were scattered about, and the other trees in the clearing, was most marked. In fairly favourable circumstances, a plantation of *officinalis*, in the sixth year, planted close, and carefully supplied, should yield 15,000 lbs. dry bark per acre, uprooted. From this amount there will in most cases have to be made a reduction for patches that have died out from unsuitability of soil. That, as a whole, plantations will exceed this age in most districts seems improbable, and all evidence tends to shew that in the sixth, or in particularly favourable circumstances, the seventh year, (that is, when the trees are rising seven years), they commence to die off in patches, individual trees alone being left which may attain any age. Where circumstances are very unfavourable, there is a critical time in the 2nd and 3rd years, otherwise the period named will generally be found the limit. In the dry climate and fine soil of Uva and

some neighbouring districts, greater longevity may be confidently expected, the absence of canker hitherto being strong evidence on the point, though there are insufficient data at present.

It is these two species, *officinalis* and *calisaya* (of the right kind),rich in quinine, which can be grown to almost any extent without fear of glutting the market. The trees may not yield so much bark as *succirubra*, which I am about to describe, but they can be planted closer, they come to maturity sooner, and from the large proportion of pure alkaloids obtained from them unmixed with foreign matter, and in a readily crystallizable form, they sell at much higher relative prices per lb. Unlike the *calisayas*, *officinalis* trees renew their bark readily when the mossing system is applied to them, the bark so renewed having a very high value, and rivalling that of the best *calisayas.* By the scraping process, however, this difficulty with the latter is now being overcome.

Elevation.

The elevation for *officinalis* is from 4,000 feet upwards in Ceylon, increased elevation improving the quality of the bark; whilst the more extreme the elevation either way, the more marked the superiority of the robust varieties. Our chief difficulty in many districts, is to get sufficient elevation without exposure to mist and cold winds. The effect of elevation is illustrated by the following figures relating to the Nilgiris,—analysis of *officinalis* at 8,000 feet gave total alkaloids 3·42 per cent, (quinine 2·10); at 6,000 feet, alkaloids 3·10, (quinine 0·75); at 5,450 feet, alkaloids 2·68, (quinine 0·45). The actual elevations here enumerated are of course not applicable to Ceylon, but the relative values of the barks grown at them are interesting.

Red bark.

The most robust species, *succirubra*, is the easiest of cultivation in every way. It shews little tendency to sport, and grows well at any elevation from 2,000 to 4,500 feet; the exact limits in this as in every case varying in the different districts.

Elevation.

The most valuable bark is grown at a medium elevation, an extremely high elevation shewing stunted trees with bark of little value, an extremely low elevation having perhaps a robust healthy tree, but one whose bark is deficient from the action of the sun. The best elevations vary in the several districts greatly, but in most cases lie between 3,000 and 4,500 feet. The effect of elevation on the red bark trees is illustrated by the following figures from one of Mr. Broughton's reports:—At 7,770 feet, total alkaloids 2·38, (quinine 0·45); at 7,660 feet, alkaloids 2·03, (quinine 0·33); at

7,450 feet, alkaloids 4·21, (quinine 0·70); at 6,560 feet, alkaloids 5·75, (quinine 2·50); at 5,450 feet, alkaloids 3.8 (quinine 1·2); at 3,500 feet, alkaloids 4·10, (quinine 0·86); at 2,300 feet, alkaloids 4·1, (quinine 0·6).

This species will flourish in a much wetter climate than *C. officinalis*, and is less liable to injury by elk and other animals, which sometimes damage *officinalis* trees considerably. It appears, however, as if *succirubra* was more liable to dying off in patches than *officinalis*, the latter shewing a greater number of vacancies through disease of individual trees.

The large amount of colouring matter and tannin in red bark, which is so objectionable to the chemist in the delicate processes resorted to in order to obtain pure sulphates, offers no obstacle to the druggist in the preparation of tonics and other decoctions. For preparations of this kind, good red bark is almost as useful as fine yellow and crown bark. The value of the latter to the manufacturer of portable and elegant sulphates, a pinch of which is equal in effect to a cupful of bark decoction, lies in the abundance of the finer alkaloids in the bark cells, and the absence or slight admixture of refractory substances such as colouring matter and tannin. In fact, the operations of the druggist on the red bark are so rough, that the residue which would otherwise be thrown away after his operations is of value to the manufacturer, and yields an appreciable amount of alkaloid. Red bark is therefore known as druggist's bark, in contradistinction to manufacturer's bark. The demand for red bark is at present good, but the enormous quantity of *succirubra* trees now growing in the island seem to foreshadow a fall in the market independently of the price of manufacturer's bark.

Yield of plantations.

The yield of bark from this species has been found very large. The published statements of results from trees on Sherwood estate Haputale shewed an average per tree of 14½ lbs. dried bark, without roots, from eleven years old trees. In Pussellawa and Dimbula, eight years old trees gave 8 lbs. of bark. At Ancumbura, Matale, ten years old trees gave 22 lbs. coppiced. In Dikoya, thirteen years old trees coppiced gave 25 lbs. In all these instances the trees were, I am sure, exceptionally fine, and though the results are most interesting, they are not as valuable as the figures given by a gentleman in Dikoya, who has realized £1,500 sterling from the produce of fifteen acres *succirubra*, three and four years old; and a gentleman in Maskeliya, who from a

clearing of four years old *succirubra*, planted 5 × 6, realised an average of Rs. 2,000 per acre. Amongst many other statements of results, kindly furnished by residents in Ceylon, I may mention the new Galway twelve years old trees, which gave 10 lbs. coppiced; and to come to trees of less maturity, in Ambegamuwa four and half years old trees gave 3½ lbs.; at Nawalapitiya three and a half years old trees gave 2½ lbs.; at Glenloch, six years old trees gave 5 lbs., &c. From good individual *succirubra* trees five years old, I have obtained 4 lbs. dry bark, root included; but the average shewn by taking the yield per tree of the whole plantation almost halved this amount. The large reduction that has to be made to arrive at the average results of whole clearings shews the small reliance that can be placed in statistics founded on the yield of isolated trees or patches of small acreage. The subject of the yield of trees in plantations is a very difficult one to enter into, and we are not justified in expecting the yield per acre to be proportionate to that of individual isolated trees. As has been previously stated, a good *officinalis* plantation, up to six years of age, should yield 1,500 lbs. dry bark per acre when uprooted, including the return from diseased trees taken out from time to time. It appears evident that in many districts a *succirubra* clearing will last a year or two longer, say to the seventh year, when, if coppiced, it should yield about 2,000 lbs. dry bark, including the root bark from a certain number of trees which have unhealthy stools, and the previous returns from diseased trees. This is the utmost that can be expected under ordinarily favourable circumstances, and in the case of large clearings, a certain proportion of the acreage will as a rule have to be deducted from the total, through unsuitability of soil. After the periods named, the increase in the amount of bark on individual trees is very great, particularly where the thinning of the plantation allows the remaining trees to grow without hinderance. These results compare very favourably with the figures from Sikkim, where seven and eight years old trees give 2½ lbs., and five and six years old trees 1½ lbs. The Nilgiris also shew a somewhat similar scale as follows:—at three years, 0·31 lb.; four years, 0·45 lb.; five years, 1·42 lbs.; six years, 1·33 lbs.; seven years, 1·93 lbs.; eight years, 2·61 lbs.

Officinalis and Succirubra compared.

As a rule, in comparing the yield of *succirubra* and *officinalis* trees, the former is considered to give about double the weight of bark that the latter gives; this

will be found about correct where, as is generally the case, the *officinalis* trees include members of all varieties; were the large leaved variety alone to be considered, the balance of yield per acre would be much in its favour, as it yields a bark of much greater weight than *succirubra*, in spite of its equally rapid growth. We must bear in mind also that this species comes to maturity earlier than *succirubra*, that the enhanced value by the mossing and renewing processes is greater, and that the market for crown bark is far more certain than that for red, all authorities agreeing in stating that the production of the former can scarcely be overdone. For one acre in Ceylon that is suitable for *officinalis*, there are ten for *succirubra*, and there is a very general fear that the cultivation of the latter may be too much extended. It is extremely probable that the prices for red bark will continue to fall as they have been doing lately, but as there can be little question that our yield per acre in suitable situations is equal if not superior to that of India, we shall be able to hold our own, and always command a remunerative price. When we consider that in Sikkim the cultivation of *succirubra* has paid well, under a system of febrifuge manufacture in which the bark is valued on the spot at 5d. per ℔.—the cost of production being put by Dr. King in his latest report at 2 annas—6 pies per ℔., we are justified in looking for a handsome profit from the cultivation. It is the quinine yielding barks, however, which ought to be produced where possible, and of these, *officinalis* is the species which has become an established success. I have stated before the results which may be counted on from trees in plantations, and it may seem small when compared with the wonderful yield obtained from isolated trees, but a little consideration will shew that it could not be otherwise. That better results than these will sometimes be obtained from individual plantations of exceptional excellence, there can be little doubt; but, judging from experience, I do not think more can be calculated on than this with safety. It is evident that the longer we leave our trees growing the greater the profit, in an annually increasing ratio, and herein will be found to lie the chief advantages of the most suitable sites for cinchona.

Value of red bark.

Of the excellence of the quality of Ceylon *succirubra* bark we have many examples. A gentleman in Rangala gives an analysis of three years old *succirubra* bark which far surpasses the average. The analysis be-

ing done in England as well as locally, and both results agreeing, its accuracy is beyond question. Total alkaloids 3·30, of which quinine 1·95, equivalent to crystallized sulphate of quinine 2·62. Mr. Downall sends the following to the *Ceylon Observer* :—"For the information of those who may wish to grow cinchona in Haputale I send you copy of valuation and analysis of *C. succirubra* bark from Monerakanda. The tree, not a picked one, was between eight and nine years old, grown at an elevation of 4,500 feet. The yield was 16 lbs. stem; 9 lbs. branch bark, *thoroughly dried.*"

The value and analysis are as follows :—

One case sorted by Messrs. Griffin as under, viz :—

No. 1. Stem, value 5s. per lb.
2. Branch, 3s. 6d. at 4s.
3. Chips with broken quill, 3s. 3d. at 3s. 6d.

CERTIFICATE OF ANALYSIS.

		per cent	1 lb = 7,000 gr., of the bark contains.
No. 1.—	Crystallized quinine sulphate	2·69	188¼ grains.
	Crystallized quinidine ...	—	—
	do. cinchonidine	1·26	88¼ ,,
	Cinchonine (alkaloid)	4·00	280 ,,
No. 2.—	Crystallized quinine sulphate	2·09	146¼ ,,
	Crystallized quinidine ..	—	— ,,
	do. cinchonidine	1·80	126 ,,
	Cinchonine (alkaloid)	2·30	161 ,,
No. 3.—	Crystallized quinine sulphate	1·47	103 ,,
	Crystallized quinidine ...	—	—
	do. cinchonidine	1·60	112 ,,
	Cinchonine (alkaloid)	2.20	154 ,,

An analysis of Lool Condura five and half years old bark is less favourable, total alkaloids five per cent with only ·5 per cent of quinine, but no doubt this deficiency was made up for by an excess of cinchonidine.

So much bark of this species has been sent to the market, that we all know the price which it is likely to realise, and, therefore, analyses are of less consequence than in the case of the more valuable species. The latest quotations for Ceylon *succirubra* bark are good renewed quill 4s. 9d. to 5s. 7d., natural quill 2s.

11d. to 3s. 6d., fair 1s. 11d. to 2s. 8d., middling 1s. to 1s. 6d., root 2s. 7d.

Red bark is peculiarly well suited to the process of renewing, as is shewn later, but until we can be certain that its lease of life in any particular locality is sufficiently long and assured to allow of the system being followed for several years, it would not be advisable to plant it with this end in view alone.

The following table of bark analyses by Mr. Broughton are of interest as shewing the comparative values of the two species :—

	Mossed Red Bark Neddiwattum.	*Renewed Red.*	*Natural Red.*	*Crown Bark Neddiwattum.*	*Crown Bark Pykara.*	*Mossed Crown.*	*Crown Bark Dodabetta.*
Total Alkaloids ...	6·20	5·82	4·45	4·32	3·42	6·60	3·61
Crys. Sulph. Quinine	0·74	2·62	0·74	3·11	2·39	3·86	2·04
ditto. Cinchonidine	3·47	0·88	1·61	0·85	0·67	1 00	0·98

There are a few varieties amongst the red barks, but they are not as numerous as those of the finer species. Of these varieties, the red flower and large leaved variety is said to be the richest, the white flower variety next, and the small leaved form poorest of all. During growth, however, the character of the tree changes, the large leaves so frequently characteristic of young plants being replaced by smaller foliage. It is doubtful whether any importance should be attached to these distinctions.

Grey barks. The consideration of the grey barks, the product of *C. micrantha*, *nitida*, *and peruviana*, need not occupy our attention much. These are all poor in the fine alkaloids, and their cultivation has been discontinued. I will, however, give Mr. Broughton's analyses of them, as they are not without interest.

C. nitida was found to contain 6 per cent of total alkaloids, of which 5.44 was cinchonine. *C. micrantha* gave 7·1 of total alkaloids, with 6·8 cinchonine. *C. peruviana* gave total alkaloids 6·25, of which 3.84 was cinchonine, and 2·00 cinchonidine. The latter species is

therefore the most valuable of the three, and were cinchonine to take a higher place in the market, the grey barks would become of considerable importance, as their alkaloids crystallize with readiness. As it is however, their introduction to Ceylon is unadvisable.

C. Pahudiana.

C. pahudiana, the species first extensively cultivated in Java, yields an utterly valueless bark, from which Mr. Broughton could only obtain ·3 per cent of alkaloid. There appears to be some danger of its being taken by casual observers for *calisaya* when young, the distinguishing mark being a thick covering of grey hairs up the half-opened leaflets.

Columbian bark.

C. lancifolia, yielding the Columbian bark of commerce, was introduced to India from Java. It made but slow growth, and consequently its cultivation was not greatly extended. It does not yield a very valuable bark, one specimen in Java gave 7·62, of which 2·18 was quinine, but this seems exceptional.

Pitayo bark.

C. pitayensis, (pitayo bark), was introduced to India in 1870 by Mr. Cross, and is said to be a very valuable species.

Hybrids.

Of the hybrids, *C. pubescens*, generally considered a cross between *officinalis* and *succirubra*, has a bark very rich in alkaloids. It has a stem free from lichens, grows very luxuriantly, and renews its bark rapidly. Mr. McIvor says of it, "Up to the present time *C. succirubra* has produced in the same period of growth more than twice as much stem bark as any other species we have in cultivation, and *C. pubescens Howard*, will produce nearly twice as much stem bark in the same period of growth as *C. succirubra*." It is very unlikely that such extremely sanguine hopes will be realized, but its robustness of growth seems undoubted. De Vrij got from a specimen of the bark of this hybrid 9·47 per cent of alkaloids, of which 5·728 was pure quinine, sulphate of quinine being 7·637. From another sample analysed by Howard, the return was 12·90 per cent of alkaloids, of which 6·94 was sulphate of quinine. A tree yielding such quantities of splendid bark is simply invaluable, but being a hybrid, plants raised from its seed are but little to be depended on as being true to type, indeed in some cases its bark is said to have been found altogether devoid of alkaloid. The preceding analyses are undoubtedly exceptional ones, and no reliance should be placed in them as fair indications of the value of *pubescens* bark. The ordinary yield of quinine that may be confidently expected is from 2·50

to 3·50 per cent. Renewal of the bark is effected with great facility, the resulting yield of quinine being from 3·10 to 4·90 per cent. In this, and in the large yield of thick bark, lies the advantage of cultivating this tree, which is greatly increased by a careful selection of stock trees. I have found the seed of this hybrid very hardy and easy of germination, the young plants growing with the greatest rapidity, and should most strongly recommend its further cultivation, by cuttings, if possible. The elevation at which *pubescens* grows is about the same as that for *succirubra*, and probably extends higher.

Mr. Howard, in his grand work on Indian quinology, has a splendid coloured drawing of a cross between *calisaya* and *succirubra*, which he has named *calisaya anglica*. It is a robust tree, yielding a quantity of bark of fair value. It appears to be commonly grown in Java.

PART III.

CHAPTER I.

CHOICE OF LAND.

The successful cultivation of cinchona depends entirely on the judgment shewn in selecting the land. Unlike coffee, which can be cultivated in soils and climates of great variety, cinchona will only flourish in soil of a certain description, and therefore it is advisable to plant it only in such land, or in such portions of an estate, as are suited for its cultivation. The climate, though of less importance, also greatly affects the degree of success with which its cultivation is attended.

Soil.

I will first consider the most important item of success, the *sub-soil.* This must be free and open, allowing a thorough drainage of all superfluous moisture that percolates from the surface. When cinchona is planted above a stiff clay, or slab rock, its death is merely a matter of time, depending on the depth at which the impervious stratum is situated from the surface. Unfortunately there is a large proportion of land in Ceylon with a sub-soil of this description, and it is throwing money away to plant cinchona on it, unless the impervious soil is situated at such a depth, that a lease of life will be allowed the tree, sufficient to enable it to mature marketable bark. As a matter of fact, no draining or deep cultivation will render this land fit for cinchona, though it may mitigate the evil to a certain extent. The richer the surface soil the better, that which contains a certain amount of quartzy and small stones being always suitable. It is the sub-soil however on which the success of the plantation depends, and too much stress cannot be laid on this point. The direction in which the strata run is an important factor in the natural drainage of land, if this is at right angles to the surface, there will be less fear of springs and damp places in the sub-soil; if, however, the direction of the strata is parallel or nearly so to the surface, the occurrence of damp places is probable. The penetration of jungle roots to a depth in the soil is a sign of suitable land. I now append Dr. King's description of the soil of the *Java* plantations, where calisaya ledgeriana has found a second

home, and which may be considered the site of the most successful cinchona cultivation in the world. "These estates range in altitude between 4,000 and 6,400 feet above the sea-level. In all of them the soil is of a dark-brown colour, light and friable, very pervious to water, and almost free from stones. The surface soil is uniform and in general deep (in some places it reaches a depth of twelve to fourteen feet), and is rich in vegetable matter. The sub-soil is lighter in colour from the absence of humus, but has similar physical properties. Both surface and sub-soil have as their basis decomposed trachytic rock rich in potash, and they were recognised by Hochstetter (an eminent German Geologist familiar with the volcanic regions of the Andes, and who recently visited Java) as almost identical with the Andesite formation of the cordillera on which cinchona is indigenous. The slopes of the hills on which the plantations stand are so very gentle that washing of soil is very slight, and landslips are almost unknown. The drainage water finds its way underground to the larger streams which separate the ridges. The absence of small superficial drainage channels is quite a feature in the country, and illustrates well the great permeability of the strata." We have in Ceylon unfortunately no soil which agrees with this description, and the numerous channels for superficial drainage are quite a feature in our case ; we have, however, an eminently suitable climate for cinchona, and in many places a sufficiently suitable soil to ensure most satisfactory results. In the Southern India plantations, the soil is of a far richer character than ours in Ceylon, but, as I shew elsewhere, the growth of cinchona here is superior to what it is there, and we may therefore feel reassured by the fact that in spite of the inferiority of our soil, we can hold our own in cinchona cultivation.

In *Jamaica* a stiff clayey soil is counteracted by the effect of a peculiar geological formation. This is described in a letter to the "Gardener's chronicle," as follows :—" The whole district is composed of white limestone on which rests a great deposit of stiff clay. Owing to the remarkably porous structure of the limestone there are no surface rivers or streams whatever ; the surface drainage is conveyed by means of sink-holes to subterranean rivers. The superabundant moisture-retaining properties of the clay soil, so prejudicial to cinchona, is

thus by natural means counteracted—*i. e.*, the subterranean drainage exerts a powerful influence upon the soil."

Mr. Hughes' letter on the subject of Ceylon cinchona soils is interesting, and I therefore give the following quotation from it:—"During my official tour through the principal coffee districts of the island in 1877 and 1878, I observed the description of soil in which cinchona appeared to do best, and from the reports I have since read, the opinion then formed, that a friable soil rich in nitrogenous organic matter was the most desirable for cinchona, has been fully confirmed. Further, the dying off of cinchona during the second year, which unfortunately has been too common in some of the districts, must be due to the stiff impervious nature of the subsoil which does not allow the water to pass off. An accumulation of water, causing a natural sourness of soil, seems as injurious to cinchona as it is to coffee. The following analysis represents the composition of a stiff impervious clay, which I personally selected during my tour. It occurred in a layer, two feet below the surface, and some three feet thick, and has been duly described in my official report to the Planters' Association, p. 151, but I think it would be interesting to give the details, with a view of pointing out the kind of soil that should be very emphatically avoided in the selection of new land intended for cinchona.

(Sub-soil Injurious to Cinchona air-dried Samples).

Water lost at 212° Fahr.	2·580
*Combined water with a little organic matter	20·220
Oxides of iron and traces of manganese...	22·206
Alumina	30·356
Lime	·084
Magnesia	·063
Potash...	·077
Soda	·094
Phosphoric acid	Trace
Sulphuric acid, carbonic acid, chlorine, &c.	Not determined
**Insoluble silicates	24·320
	100,000
*Containing nitrogen	·048
**Yielding on subsequent fusion potash ...	·482

This analysis shews us a soil containing over 50 per cent of clay, with 30 per cent of alumina. There

is a total absence of quartz crystals, which form so prominent a part in the majority of good Ceylon coffee soils ; moreover, there is a marked poverty in lime, potash, magnesia, and soda.

The insoluble silicates, unlike the insoluble portion of granitic soils, do not yield much potash on subsequent fusion, and in this respect form a striking contrast to the soils presently to be mentioned.

Passing on from the examination of this dangerous subsoil to the consideration of those soils which appear likely to prove suitable to cinchona, it may be remarked that this is a subject which so far appears to have received little official attention from the agents of the Government; so far as I am aware no anlyses of the famous soils of the Hakgala Government cinchona plantation have been made; and it is not known whether the several proportions of the valuable alkaloids produced from the bark have been systematically determined. Planters naturally look to Government for help and guidance in such matters, and at the present time of short coffee crops Ceylon planters want all the assistance that can be given them with the aid of a Government chemist and botanist.

Soils naturally rich in decayed vegetable tissues, with a good friable texture and containing the important mineral elements in fair proportions, are those which doubtless abound in the mountain regions of South America, where cinchona flourishes with such prolific luxuriance. We should therefore make a selection of such land as seems best calculated to supply these natural advantages, and with a stimulating climate and a heavy annual rainfall there is every reasonable prospect that Ceylon will eventually be found admirably adapted to the production of bark rich in quinine. I beg, therefore, to direct attention to certain representative soils taken from different districts, some of which have already proved well suited to cinchona.

CEYLON SOILS SUITABLE TO CINCHONA (AIR-DRIED SAMPLES.)

Name of District Elevation.	*Haputale.* 4,700 ft.	*Matale.* 4,000 to 4,250 ft.	*Dimbula.* 4,800 ft.	*Dimbula.* 3,200 ft.
Water lost at 212° F	3·850	3·680	5·950	3·680
*Organic matter and water of combination	8·750	11·860	13·444	8·380
Oxides of iron and some manganese..	6·798	7·631	9·265	4·530
Alumina ...	6·502	8·969	12·108	4·993
Lime	·266	·257	·136	·350
Magnesia ...	·153	·576	·118	·216
Potash	·139	·212	·173	·115
Soda	·020	·003	·075	·062
Phosphoric acid ...	·185	·140	·099	·147
Sulphuric acid ...	·062	trace	·097	·003
Carbonic acid and Chlorine ...	*	*	*	*
Pure quartz crystals.	20·120	29·120	17·197	26·800
**Insoluble silicates	53·155	37·552	41·338	50·724
	100·000	100·000	100·000	100·000
*Containing nitrogen	·213	·328	·265	·219
**Yielding on subsequent fusion:—				
,, Potash ...	1·941	1·853	*	1·767
,, Soda	·246	·544	*	·754

If these analyses are carefully compared with that of the stiff clay already recorded, it will be seen where the differences in the composition exist.

Thus the free nature of the soil is very fairly indicated by the presence of quartz crystals, which varies from 17 to 20 per cent, as also by the relative low amount of alumina, the leading constituent of clay. The portion of alumina in no case exceeds 12 per cent, as compared with 30 per cent in the former analysis. The oxides of iron do not exceed 9 per cent, as opposed to 22 per cent, and we notice a much higher proportion of potash both in the quantity soluble in acid as well as a form ultimately rendered available by the decomposition of the at present insoluble silicates. Further, there is a relative high propor-

tion of phosphoric acid, of course not so high as in soil formed from sedimentary geological formations, but high as compared with poor quartz soils or stiff clays.

In the former analysis we would not expect much nitrogen, the clay being a specimen of sub-soil taken at a depth of about one and half to two feet below the surface ; we cannot therefore compare the high amount of nitrogen which we see is present in these specimens rich in humus with the small quantity found in the clay. The comparison would not be fair, one being a subsoil, and the other surface ones. We may remark that the percentage of nitrogen will be an important point for consideration in judging of the relative advantage of different samples of soil on new estates."

Sites.

The best cinchona is undoubtedly grown in forest-land, or amongst coffee the soil not having been previously exhausted or washed away. On sites where coffee has been abandoned through exhaustion, or original poverty of the soil, as a rule it is useless and unreasonable to expect cinchonas to grow profitably. There are, however, exceptions to this, notably the case of quartzy ridges, which are often found to grow cinchona luxuriantly when coflee has proved a decided failure. From the great luxuriance shewn in the growth of cinchona amongst good coffee, and the superiority it appears to possess over that grown in virgin soil in some localities, one cannot help fancying that the opening up of the soil by the coffee roots, and by cultivation, where the process has been continuing for some period previously, is one of beneficial, rather than of detrimental effect to the soil in regard to its suitability for this cultivation. There are certainly some soils, insufficiently free at the outset for cinchona, which are rendered more suitable by a course of cultivation with another product such as coffee. This explanation is rendered more probable from the fact that amongst coffee, the liability to decay during the later periods of growth seems less than elsewhere. In view of this, and the fact that properly pruned, cinchonas do no harm to the coffee under them, I should urge on all interested in coffee cultivation, to plant up their fields with the species best suited to the climate, putting them closer together in proportion to the inferiority of the coffee. It is also a wise plan to replace the worn-out coffee trees, so numerous in all old estates, and which cannot possibly repay cultivation, with a small clump of cinchonas. This plan, systematically pursued, will add greatly to the appearance and value of

the estate. One great element of success is the selection of large plants for this purpose,—small ones are quite useless and are sure to fail,—which should be carefully protected from injury by strong pegs. From what I have seen, *succirubra* appears to grow better in old coffee than *officinalis* does. On patena land cinchonas, especially *officinalis*, grow well apparently, particularly where the soil has been dug up and limed; whether they will reach any considerable age in these situations is doubtful at present. It is the free gravelly patenas alone that are suitable, the well-known black patena soil being quite unsuitable.

Lay of land

That cinchona will not grow in flat land is well known, that the unbroken side of a large hill is scarcely suitable is not so generally recognised. It is essential that the sub-soil moisture be drawn off as soon as possible; the face of a hill, unless broken by ravines down its sides, which draw off moisture from the undulations of land between them, must be more affected by accumulations of damp the lower you descend, and we therefore find that the sides of hills, unless broken, are rendered more or less unsuitable by the accumulation of moisture from above, which is not drawn off into natural channels. The most perfect lay of land for cinchona is that afforded by a "hog's back" of land, having a slight slope from end to end, and affected by the double drainage afforded by a ravine on both sides. The face of a hill, well broken up by ravines, is also suitable.

The two considerations I have just discussed, soil and lay of land, are of paramount importance in cinchona cultivation, and unless these conditions are suitable, it is far better to plant something else than to court failure by planting cinchona. In the case of a clearing specially intended for it, it is advisable to plant all unsuitable portions, of which there will inevitably be a certain proportion, with tea or coffee, and thus anticipate the ugly spectacle of patches of dying trees, which so mar the appearance of an otherwise beautiful sight, a plantation of flourishing cinchona. It must also be borne in mind that though canker is not an infectious or contagious disease, still the presence of trees suffering from it through damp in the soil, implies the existence of numerous fungi; these cannot but have a deleterious effect on trees in the neighbourhood, which would otherwise be healthy. On coffee estates, it is still more evident that suitable portions only should be planted with cinchona.

Exposure.

Exposure to the wind is undoubtedly an evil, but by no means as great a one as is generally supposed; and it so happens that the red barks, which are the ones most injuriously affected by it, can be grown at elevations where wind is unknown. The crown and yellow barks suffer least of all, and it is these species which are sure to become exposed to more or less wind at the elevations which are suitable for them. By judicious pruning or staking the effects of wind can be minimised, and experience has shewn us that we need not anticipate more than a certain retardation of growth in consequence. There are some situations, however, exposed to the fury of wet mist-laden gales, where the effect is disastrous; but moderate wind, unaccompanied by excessive moisture, is not to be feared. I do not mean to maintain that a sheltered situation is not far more valuable than an exposed one, but simply that, other circumstances favourable, an exposure to moderate wind is but a trifling drawback.

Aspect.

In every district I have visited, an aspect more or less inclined to the East seems most suitable, the few yards traversed in going from one side of a knoll to another often shewing a marked contrast in growth.

Rainfall.

Cinchonas will stand a considerable amount of rain, and are also unaffected by long droughts. But in both of these instances, the deficiency or excess of moisture must be compensated for by advantages of aspect, position, and drainage. Showery weather is most suitable for the growth of cinchonas, long-continued rain being decidedly injurious, but continuous drought less so. In a wet district, cinchona may be profitably cultivated on a naturally well-drained piece of land, if not too much exposed. Unless these two conditions are fulfilled, its cultivation will prove a failure. A dry district on the hills will have about the amount of rain required by cinchona, say 80 to 100 inches, the more evenly dis-distributed the better, and in this case exposure is less to be feared. The climate of Uva, and the drier portions of Maturata and Upper Hewahette, seem eminently suited to cinchona cultivation, that of *officinalis* especially; the latter districts affording instances of trees whose dimensions seem to exceed those elsewhere. The extent of country suitable for *succirubra* cultivation is very large, and appears to embrace almost all the districts. The growth of this species is everywhere so great at the proper elevation that it is almost impossible to point out one district as being superior to others, on

local circumstances does its success appear to depend. In Dikoya, however, may be seen trees of this species which can hardly be surpassed elsewhere in any respect.

It is a noticeable fact that in a dry climate, such as that of the districts previously mentioned, cinchonas do not die off in patches as elsewhere ; individual trees become diseased, but the wholesale loss of large patches is comparatively rare. This fact, coupled with its undoubted superiority of soil, appears to indicate that Uva, using the term in a broad sense, will be the country for cinchona as for coffee.

The elevation at which the various species thrive best depends greatly on the district, the limits being more extensive in a dry than in a wet climate. As I have touched on this subject before when discussing the various species, I will merely sum up the information briefly. For *calisaya* from 3,000 to 5,000 feet probably ; *officinalis* from 4,000 feet upwards, the robust variety growing well at a lower elevation; *succirubra* 2,000 to 4,500 feet. Between these limits a zone will be found in each district of greatest suitability. Elevation,

The comparison between the climates of Ceylon and other cinchona-growing countries is a very interesting subject, and in this connection I will give an extract from a late article in the *Ceylon Observer*, speaking of red bark trees, it says :—" In the account of the experiment tried on the Khasia hills, we find it stated that these plants grew freely from 4,800 feet (above which the cold was too much for them) down to 800 feet,—down, in fact, to the level of the plain of Assam, which is but slightly elevated above sea level. Here as elsewhere, however, the trees refused to grow on perfectly level ground. We have information as to the quality of the bark grown so low as 800 feet. The difference of latitude, however, and the effect of that difference have to be taken into account. The influences of local aspect, shelter, &c., are so powerful, that we suppose no fixed formula can be adopted to shew the equivalents of altitude and latitude. But we can refer to a very interesting case which must largely govern that now referred to. In round numbers, the mean temperatures of Dimbula at 4,600 feet, and the Rungbee Valley in British Sikhim, 20° further north, are represented by the same figure, 65.° The difference of altitude between the two places is 1,268 feet, Rungbee being so much lower than Dimbula, and Dimbula so much higher than Rungbee. For each parallel of latitude, therefore, there is a fall or a rise, as the Comparison between Ceylon and other countries.

case may be taken, of somewhat over 63 feet. The difference of latitude being as nearly as possible 20°, Dimbula being in 7°, and the Khasia Hills, like British Sikhim, in 27°, we have to multiply 20 by 63 to get the equivalent in Ceylon, at 7° from the equator, of 800 feet in Assam, 27° north of the line. We therefore find that to get the same conditions of temperature as exist at the foot of the Khasia hills at 800 feet altitude, we must not go lower in Ceylon than 2,060 feet: indeed, 2,100 would be nearer the mark. It would seem, therefore, that, even if *C. succirubra* not only grows readily but yields good bark in north-eastern India at 800 feet, we cannot expect equivalent results here below 2,000 feet."

Java, which is situated as many degrees South of the line as Ceylon is north, has at 500 feet a mean temperature of 63° Fahr., which it appears is almost exactly the temperature of the same elevation in Ceylon, and the two countries may therefore be considered as identical with regard to elevation. The range for *ledgeriana* and *succirubra* is given as from 4,000 to 5,000 feet in both cases, the latter being given another 500 feet, and *officinalis* from 5,000 feet upwards. It is probable that *succirubra* could be cultivated profitably at a much lower elevation, as in Ceylon, but the chief interest lies in identity of the elevations for the two species, and the probability that in Ceylon, *ledgeriana* can be cultivated at a much lower elevation than we had previously supposed.

In the matter of elevation, a curious anomaly is presented by *calisaya schuhkraft* in Java. This variety gave the same analysis whether grown at 400 feet or 5,000 feet above sea-level, namely 6·46 per cent total alkaloids, consisting of quinine ·73, quinidine ·38, cinchonine 4·00, amorphous alkalaids 1·35. It also appears that the bark of this variety does not improve on renewal. It is of course a tree of very low value, but it possesses a peculiar interest from its insusceptibility to climate, and hence is worth a passing notice in this connection. It seems possible that other kinds of cinchona may be found capable of growing at low elevations without losing greatly thereby.

CHAPTER II.—FELLING AND CLEARING.

The time for felling varies in the different districts, in those getting the South West monsoon rains it should

be finished before the end of December; where the North East rains are trusted to, it should be done much earlier. It is of great importance that the clearing should be burnt early, so as to allow ample time for all the necessary work that precedes planting, and on this, the success of the clearing in great measure depends.

Contracts.

It is usual to give this work out on contract, for Tamil coolies are very inexpert with the axe, and the Sinhalese will do it much cheaper and better. There are two ways of giving the contract: in the one case, the contractor merely undertakes to fell, lop, and set fire to the clearing, after which his responsibility ends; in the other, he takes the chance of the burn as it is called, and if this is unsuccessful, either by the wood and leaves being too green, or by imperfect lopping, he has to heap and burn it again at his own cost. The latter is by far the better way, and is now universally adopted, as it saves the superintendent a great deal of responsibility, and the estate the possibility of considerable loss; for, when the contractor is not responsible for the burn, he will not do more lopping than he can possibly help, and some of the more inaccessible parts of the clearing will probably be quite green underneath, the consequence of which will be a bad burn. Rs. 17·50 and Rs. 20 per acre are the rates usually paid for felling and clearing up-country

Sinhalese method.

The method employed by the Sinhalese in felling is as follows:—They first cut down all the undergrowth and small trees with catties; they then commence upon the large timber, making two incisions, one on each side of the tree, the one on the upper side being about half a foot higher than that on the lower side; this tree is left standing, and others are similarly treated, until several acres are done; a large tree at the top is then sufficiently cut through to fall on those near it, these in turn catch in ones lower down, and in this manner several acres are frequently brought down at one time. When the stems are very large at the bottom, but diminish in size about eight feet or so from the ground, they make a small stage to stand upon, and by cutting high up, lessen the work of felling heavy timber considerably. When the felling is done, the branches of the trees are cut off, and made to lie as evenly as possible, so that there shall be no obstruction to the course of the fire, and the clearing is left until the sun has dried it sufficiently, when the firestick is applied. This lopping should be done simultaneously with the

felling, as the branches are much more easily cut when green than when dried by the sun. A bad burn as it is called, or one where a quantity of jungle stuff is left unburnt, is better than a fierce one, where the humus on the surface is scorched. A good burn is one in which all the small branches and jungle stuff are burnt, leaving the soil in some places white from the deposited wood ashes, and in others a black colour. Wherever the ground looks red, the fire has been too fierce. The length of the time which must elapse between the lopping and burning varies considerably. In some districts it is longer than in others, whilst a clearing situated amongst surrounding forest takes longer to dry than one in a more open position. When the jungle to be felled adjoins cultivated land,a belt should be left standing to arrest the progress of the fire. After the clearing has been burnt, these belts should be felled and burnt, and all jungle stuff that has escaped the fire, and there is usually a quantity of it in the ravines, should be heaped and burnt.

The contractors should not be allowed to leave any dead trees standing about the clearing, as they are very fond of doing from the difficulty of cutting them, for they will soon get rotten, and being blown down by the wind, or cut down by coolies for firewood, will do considerable damage.

CHAPTER III.—WEEDING.

This work is by no means as important in the case of cinchona as of coffee; indeed, in India and in Java, the method pursued appears to be as much opposed to our ideas of high cultivation as any thing can be; two or three "cuttings" per annum are spoken of, until the trees are sufficiently high to render weeding unnecessary,

On clean ground.

There is no doubt, however, that in case of clearings on forest land, where after the burn but few weeds are to be met with, it is better to keep the ground free from them by frequent periodical weeding, as in the case of coffee clearings, than by neglect to allow them to infest the ground with seed. In steep land, hand-weeding should certainly be enforced to prevent loss of soil, but on comparatively flat land, the use of scrapers, if it effects any material reduction in the cost of work, is unobjectionable, and to a certain extent beneficial.

On weedy ground.

In the case of a plantation on naturally weedy ground, such as abandoned coffee, or chena, I should certainly

advocate the system of weeding at long periods as practised in India, and deprecate the expenditure of large sums on the attempt to eradicate the weeds; for when once the trees shade the ground effectually, the growth of weeds is greatly checked, and such as do grow, if left on the ground when cut, enrich rather than impoverish the soil. For the first two or three years the weeds must be kept down, or they would interfere with the growth of the young trees, and the cheapest method should be pursued in effecting this. On clean ground frequent weeding is the most economical in the end; on weedy ground the work should be performed at longer intervals, but sufficiently often to prevent the weeds from choking the plants. In the latter case it is sufficient to weed round the plant for about a foot, every month, clearing up the rest of the ground at longer intervals. Grasses such as ilook, and jungle stuff whose roots would be likely to strangle the young trees, should be eradicated at the first. These grasses are very difficult and expensive to get rid of, as the root remains in the ground unless dug up with a pickaxe; they die in time, however, if the shoots are persistently pulled up as soon as they appear above ground. In considering the advisability of the use of tools for weeding, it is well to remember that a slight stirring of the surface soil is decidedly beneficial to cinchona trees, even when they have attained their full size.

In dry climate.

The question of whether weeds, in a climate subject to drought, have an injurious effect on the cinchona by depriving it of moisture in the soil, has two sides to it. During dry weather, plants are supplied with moisture from the soil below the surface, which acts as a reservoir for it, and if the surface of the soil is exposed to the sun, this reservoir of moisture is very soon exhausted by evaporation, and the ground becomes hard and baked. The loss arising from this cause is a very much more rapid one than that occasioned by a covering of weeds, which, though they absorb moisture for their own support, keep the ground from the baking heat of the sun. The deposit of dew also, supplied by nature during dry weather, is absent unless the ground be carpeted with vegetation. There can be no question, therefore, that in this one particular, weeds have not an injurious effect, but rather a beneficial one.

Contrary to the practice in the case of coffee, earth should not be allowed to be heaped round the

stems above the collar in weeding; for sometimes when the stems are so covered, fermentation sets in during wet weather, which is followed by a fungus attacking the bark, and ultimately causing the death of the tree. This matter is referred to again later.

On the Nilgiri plantations, self-sown seedlings are all carefully eradicated. No doubt cinchona seedlings, equally with coffee seedlings, exhaust the soil to a certain degree of the principles necessary to the heathy life of the older plants, but as they have a considerable value, being hardier as a rule than nursery plants—Rs. 2,000 per acre having in one instance been realised from this source alone—it is advisable to allow them to grow up to the time when they are marketable. A certain proportion should also be left in the ground to take the place of diseased trees.

Cost. The cost of weeding in the case of a forest clearing is about 50 to 75 cents per acre per month according to the climate; on land weedy through previous cultivation, an expenditure of Rs. 2·50 per acre, four or five times a year, should be sufficient in most cases, with a small extra amount for clearing round the plants every month.

Ravines. The weeding of ravines is a matter that depends entirely on the pocket and inclination of the planter, it certainly adds greatly to the appearance of the estate, and in most cases at a trifling cost. The most profitable use for them is the cultivation of a material to assist the renewal of bark; as I shall shew later, maana grass appears to be the best substitute for moss, and if the ravines are drained, this may be grown in them very successfully.

CHAPTER IV.—ROADS.

On a cinchona plantation, the roads need not be as numerous as on a coffee estate, as there is far less work to be done after the planting is finished in the former, than in the latter case. What roads there are should be well cut and carefully traced, as then they greatly improve the appearance of the estate, besides performing an important function in the drainage system.

Width. They should be four feet wide in the solid,—a greater width than this is so much wasted space,—and so arranged as to open up every valley if the land is undulating, or, where it consists of one or more steep

faces, to make all parts of them accessible. The best gradient for roads in a clearing is 1 in 10, if steeper than this the side drains are cut by the rush of water, and the road undermined. Gradient.

Before commencing to road a clearing, the whole should be roughly surveyed, to determine the most suitable positions for the principal roads, otherwise some mistake is sure to occur. Where a road is wanted to be on one gradient, and to look well, the cutting should never be commenced until the whole trace is laid out. For frequently in tracing a road, rocks and other impediments are come across, which it would be difficult and expensive to pass, without changing the gradient so as to go either above or below them. In this case the only plan is to commence from the beginning, and trace the road anew, so as to avoid the difficult place; but, if any part of the road has been cut already, an inequality of gradient is unavoidable. Every one knows what a finish well-traced and well-cut roads give to an estate, and how much its appearance is improved thereby; careful tracing is therefore an expenditure of time and trouble which amply repays itself. In ordinary soft land which is not steep, a cooly can cut one chain of a four-foot road, provided men have been sent ahead to roll away the trees that cross the road, and to take out the large stumps. In addition to the men engaged in earth-cutting, axe-men should be allowed; where the ground is not unusually full of roots, one axe-man to ten earth-cutters will be sufficient. In tracing a road, two kinds of pegs are necessary: short thick ones to shew the level, which are best made from "warraches" (straight jungle sticks) cut into lengths of about six inches and sharpened; and longer ones, such as those used for lining. A man should be placed with the sighting pole at the point from which the road is to start, and the first sight taken at about thirty feet distance; when a place is found slightly lower than the required level, a peg should be put in and hammered till the tracer, resting on the top of it, sights the arm of the sighting pole. A long peg should then be driven in to indicate the position of the level-peg. The sighting pole should then be moved to the top of the level-peg just put in, and another sight taken at a distance of about thirty feet; from this point again another level should be taken, and so on. Tracing.

When the coolies have been given their tasks, before allowing them to commence work, the superintendent Cutting.

should draw a line with a stick to shew where the cutting should be commenced ; it should pass above each level-peg at a distance rather more than the required breadth of the road, but varying in accordance with the steepness of the hill, and all coolies should be forced to commence cutting at this line, working lower and lower until they reach the required level. They should not be allowed to commence cutting close to the peg, as this enables them to shirk work by cutting the road narrower than it ought to be. The earth-cutting being finished, a few coolies are necessary to blast and remove the rocks, and to level and smooth the surface. They should also be made to slope the road inwards, so that the rain-water will run into a back drain, the size of which depends on the amount of wash that is probable.

Drain. For most roads, a drain one foot broad and deep will suffice ; and of this a cooly can cut 120 feet. At intervals, the frequency of which depends on the probable rush of water, cross-drains should be cut, carrying the water the whole way into the nearest ravine. There are several ways of making these. When they are necessitated by a natural ravine crossing the road, the best kind is the open Irish drain, consisting of large flat stones, evenly laid, and sloping from the sides to the middle, and also with a slope toward the outside of the road, the interstices of the stones being filled with smaller ones hammered in. This is a good form of cross-drain in every place where a rush of water is probable ; and if it is made sufficiently broad, say six feet at least, a horse has no difficulty in crossing it, the slope from each side being gentle and not abrupt. In making a covered drain, which is not so good a kind as the open one, as it is liable to become choked up, a trench, one foot wider and deeper than the drain is required to be, should be cut across the road ; the bottom should then be paved with stones, and the sides made, if possible, of rows of single stones, each as high as the drain is required to be, with small pieces hammered in between them ; where smaller stones are used, and are built one upon the other, the strength is much lessened. Above these walls, flat stones should be laid, covering the trench, and projecting on each side to the extent of half its width. All fissures must then be filled up, and the whole covered with earth.

Bridges. In flat land, bridges are often necessary for crossing ravines, and are easily made from the trees lying about in a clearing. Where there is a good foundation on

each side, rough stone abutments should be built; and when the height is not great, some coolies can make these sufficiently well. Where, however, the ground is swampy, a foundation can be made by throwing down five or six logs, parallel to each other, and then some more across the top of them. A few layers of timber placed in this manner will be sufficiently firm to offer a foundation for the abutments of the bridge, which had better, in this case, be made of trees instead of stone. I may mention that if a hard wood be chosen, the logs immersed in the swamp will last for many years without rotting; but it is a good plan to char their outer surfaces before laying them down. The bridge itself should consist of three large trees, whose diameter depends on the width of the ravine, with their upper surfaces smoothed; across these other trees should be laid, or, what is better, the outside planks from a saw-pit, which should be fastened on with nails. The whole should then be well tarred, and covered with earth.

The cost of such roads depends on the nature of the land, and on the completeness with which they are finished off; Rs. 110 per mile is an average rate. Cost.

CHAPTER V.—DRAINING.

This work should, like roading, be finished before the planting, and its effectual performance is a matter of great importance to the success of the clearing. As I have before stated, cinchona should only be planted in land having an open porous soil, and a sloping exposure. The object of draining in this case is to prevent the loss of the friable surface soil by wash. In many cases, however, we find cinchona planted in unsuitable land, and dying out in patches in consequence. Excessive moisture is always the cause, and where the evil is an extreme one, I should advise an abandonment of the cultivation, and the substitution of something else, tea for instance. Some good may, however, be effected by draining, and I will consider the matter shortly. Objects.

On suitable land with an open sub-soil, the amount of wash would ordinarily be small,—the water percolating through to a lower stratum, and not accumulating near the surface,—but for the heavy falls of rain to which we are liable in Ceylon, and which make it necessary to guard against the wash that always attends them. Besides the loss of soil which results from Wash.

surface wash, the mechanical action of the water on the stem of the tree causes disease, as I shall shew later, and it is therefore absolutely necessary to guard against it. For the prevention of wash, drains should be broad and shallow, and not so far apart as to allow the surface water to accumulate. In most cases 20 inches broad, 12 inches deep, and 40 feet apart will suffice, the gradient being 1 in 15.

Impervious Soil.

In the case of a more or less impervious sub-soil, the only chance of getting the cinchona to grow is to endeavour to dry the soil, and abstract as much moisture from it as possible by means of drains. For this purpose they should be at least 2 feet deep, 18 inches wide, and at a gradient of 1 in 10, or even steeper. The closer together they are put the better; 30 feet apart would probably not be found a bit too close. Cross-drains should also be cut at frequent intervals to give increased effect. My own experience has taught me that not even such close draining as this will cause cinchona to grow on very impervious soil, but I have no doubt that in many instances, where the evil is not excessive, the remedy will have some effect.

Tracing.

In tracing a drain much care is required, and the ground through which it is to run should be examined beforehand, not only with a view to the discovery of what kind of drain is most suitable, but to ascertain that its course is free from such obstructions as rocks and large tree-stumps; for, on encountering an obstacle of this kind, the whole drain must be traced again, as the point at which a change of gradient occurs is one liable to break out with an unusually heavy rush of water. No level pegs, such as those used for roads, are necessary for making the trace, but stakes should be put in with a tracer, at intervals of about thirty feet, to mark the course of the drain. As in road cutting, a line should be made with a stick from peg to peg, at which the coolies are to commence cutting so as to make the drain below the stakes, instead of them above as in roads. When the drains have been cut at easy gradients they are liable to silt up and break out, a man should therefore be constantly employed clearing them out in wet weather, and spreading the silt so obtained round the trees below the drain, so that it shall not be washed back again. Natural ravines should if possible be chosen into which the drains may empty themselves, a point on the hill being chosen from which each drain may descend on either side to the natural ravines. When, how-

ever, their length would be too great to admit of this, or where the stiffness of the soil makes it desirable, the face of the hill should be divided by outlet drains, two feet wide and deep, into which the smaller drains may empty themselves. Care must then be taken to make them enter alternately from either side, and not in pairs, and to increase the steepness of the gradients within a few feet of the end, otherwise the sides of the outlet drain will be undermined.

On a hill side, a cooly can cut one chain of a drain 20 inches broad, and 12 inches deep, in soft ground; and thirty-six feet of one 2 feet deep, and 18 inches broad. Task.

The rule for calculating the length of drains in an acre is to divide 43,560, the number of square feet in an acre, by the distance between the drains; the result is then in linear feet. As this applies to surface acreage only, an addition must be made for steep land. I append a table compiled in this manner, shewing the number of feet per acre of drains at distances ranging from twenty-five to sixty-five feet :— Calculations.

Distances between Drains in feet.		*Linear feet per acre.*
25	...	1,742
30	...	1,452
35	...	1,244
40	..	1,089
45	...	968
50	...	871
55	...	792
60	...	726
65	...	670

Drains 20 inches wide, 12 inches deep, and forty feet apart, will cost about Rs. 7·50 per acre; if 2 feet deep, 18 inches wide, and thirty feet apart, Rs. 17·50 per acre. Many old coffee estates which are now being supplied with cinchona have never been drained. When possible it is certainly advisable to put in drains before planting the cinchona, but if this cannot be done, a small semi-circular drain should be cut above each plant, to protect it from wash. Cost.

CHAPTER VI.—LINING.

In opening land for coffee, when regularity in the position of the trees is of great importance, lines of pegs are driven in to mark the spots at which holes for the Object.

reception of the plants are to be cut. For cinchona this work is not of such great importance, but it is convenient to have the trees in lines at uniform distances, and regularity of position improves the appearance of the clearing; besides which, the supervision of the subsequent works of holing and planting is greatly facilitated. It must also be remembered that future valuations of the plantation are rendered much easier, and probably more favourable, by a careful performance of this work. I shall therefore indicate the various methods of lining generally employed, which may be modified by the omission of alternate lines of pegs, or of alternate pegs in each line; this modification may be employed with greater advantage when the trees are planted very close. Thus, if a clearing is to be planted $3\frac{1}{2} \times 3\frac{1}{2}$, it should be lined $7 \times 3\frac{1}{2}$, the lines being seven feet apart, but the pegs three and a half feet apart along the lines. In this case the unmarked lines should be holed first, otherwise it becomes difficult for the coolies to hole straight.

Lining may be performed in two ways: either by cross lining, when the rows of pegs lie evenly in several directions, or by simple lining, when they are even in one direction only. The former method is sometimes employed in small clearings, and I will give a description of two ways of performing it. A strong thin rope should be procured, about 250 feet in length, and the intervals at which the pegs are required to be put, marked by small pieces of cloth, inserted between the strands. Two lines of pegs must first be put in, straight up and down hill, the distance between the lines being equal to their length; and connecting their ends at top and bottom, two other rows so as to form a square; to do this, and to get the lines at right angles to one another, a prismatic compass will be of great assistance. The square once made is easily filled in by stretching the rope between the corresponding pegs in the top and bottom lines. The rope must be made to lie perfectly straight before the pegs are put in, and, should it not reach the pegs at either end, in consequence of being placed on the top of a rock or stump, the pegs may be moved slightly backwards or forwards in a line with the rope, so as to keep the cross lines even. Other squares can now be added on to the original one until the clearing is finished. This is not as accurate a method as the ten-rope system, which I will now describe, but it is more quickly done,

Cross Lining.

and is sufficiently correct. In the ten-rope system, a parallelogram is laid out instead of a square, the extreme length being up and down hill, and the transverse ropes being of such a length as to admit of the required number of pegs, usually ten, being put in along them. Coir ropes are then stretched from each peg in the lower line to the corresponding peg in the upper line. The ground is now crossed up and down hill, by ten or more ropes, with others crossing them, one at the top, and one at the bottom. Two men now go along the outside ropes up the hill with a rope stretched between them, with which they connect each pair of marks; while boys put in pegs at the spot where the moveable rope crosses the coir ones. This method, though difficult to describe, is in reality very easily performed.

Simple lining.

In simple lining, two base-lines are first put in through the middle of the clearing, at right angles to one another; and the four divisions thus formed filled in by lines of pegs, parallel to one or other of the base lines.

Pegs.

Where old cinchona trees have been cut into lengths for barking, these will be found well adapted for splitting into pegs, and a cooly can cut 1,000 pegs from them in a day. From jungle trees, 600 pointed pegs is a fair task.

Cost.

The cost of simple lining depends on the intervals between the pegs; the following table will be found fairly correct:—

Distance.	*Trees per acre.*	*Cost per acre.*
3½ × 3½	3,556	Rs. 8·00
3½ × 7	—	4·00
4 × 4	2,722	7·00
4 × 8	—	3·50
5 × 5	1,740	4·50
5 × 10	—	2·25
5½ × 5½	1,440	3·75
6 × 6	1,210	3·25

CHAPTER VII.—HOLING AND FILLING.

Reasons for and against holing.

The holes for cinchona plants need not be of great size, the soil in which they are planted being naturally free and open; if it is not so, it is still injudicious to cut large holes, as they then become receptacles for water and probably kill the plant. In fact, it is the opinion of some planters that canker is due to holing.

This may be true to a certain extent, and in certain circumstances where the soil is stiff, and the tree dies off when quite young, but wherever the soil is of such a nature that holing can have an injurious effect, cinchona should not be planted, as in any case it could not survive long; this theory cannot therefore be accepted in general. In suitable soil I have found plants receive marked benefit from holing. To ensure the removal of roots and stones from immediate proximity to the young plants, and to facilitate the operation of putting them in the field, it is well to cut small holes, which should be filled and heaped with surface soil sifted through the hands, and thus freed from lumps of earth, stones, and roots. Foot holes, of which a cooly can cut about 100 or more in easy ground, are sufficient.

Filling.

The filling in should be done carefully by women and boys with soil freed from roots and stones.

When alternate lines only have been pegged out as has been advised in close planting, the unmarked lines should first be holed, the coolies being provided with sticks to shew the distance between the holes.

Season for holing.

Holing ought not be done till the end of the hot weather, and the beginning of the rains, except where a clearing is so large that time is an object; for when the ground is damp, the work is much easier for the coolies, and in addition to this, the hot sun has an injurious effect upon the holes, particularly if the sides are of a clayey nature, as they become baked and hard, obstruct the young roots, and retain moisture; whereas exposure to the weather during the rainy season is beneficial.

Holing gauge.

For measuring the holes, each kankani should be provided with a gauge, which is constructed as follows:—A five foot reaper is crossed at the bottom by a piece of wood as long as the breadth of the hole at the bottom; above this, and parallel to it, at a distance equal to the required depth, another piece of wood is fastened, of the same length as the breadth of the hole at the top; these two cross pieces are then connected together. A gauge of this kind is an easy check on the size of the hole, which should be sufficiently large to allow of its being turned round freely. One axe-man to cut the roots should be allowed to every ten coolies or so, and it is a good plan to provide each of them with a gauge, and make him responsible for the size of the holes cut by his men.

Where cinchona is being planted amongst old coffee, the soil of which has been made loose and free by forking and such operations, it is unnecessary and very expensive to hole; for to check the work of the coolies when the holes are cut at such irregular intervals is impossible, and I have therefore always found the plan of giving the coolies plants, and making them dig the small holes necessary to contain them at the time of planting, the most satisfactory arrangement in every respect. Amongst Coffee.

A method of planting has been suggested in the *Ceylon Observer*, which it is probable would reduce the loss by dying off considerably; the expense however would be very great. It is as follows:—"Fell and burn a clearing, reducing to ashes all the logs possible. Dig in the result (which will contain a quantity of lime), and then add a second coating of burnt coral lime. Turn over soil a second time, trench, and dibble in plants with pointed stick or mamoty. The charcoal in the soil will first gather to itself, and then give out ammonia, a great stimulant to produce of alkaloids." On patana land a similar process to this has proved a decided success; the plants (officinalis in the instance I refer to) shewing remarkable vigour of growth. Lining and forking.

CHAPTER VIII.—PLANTING.

By far the most important work is planting, and it is one that requires the almost undivided attention of the superintendent, for it is a work at which coolies are careless unless properly supervised, and on it depends in a great degree the success or failure of the clearing.

The best months for planting vary in the several districts, but early planting is as a rule best, for in addition to the time thus gained, there is plenty of opportunity afforded for supplying vacancies. Very wet weather is not suitable, as the earth in the holes becomes too full of moisture, and the plant does not thrive; it is better to choose a showery day, intervals of sunshine alternating with light rain. Season.

In opening a clearing when the plants have to be transported from a distance, they should be kept in shaded baskets, the roots in soil, and be constantly watered during the

Planting.

journey. In planting them out they should be put into the holes by hand, without the aid of tools, and on the degree of care with which this is done the fate of the plant chiefly depends. Holding the plant in the left hand, the cooly makes a hole in the loose earth with the right, into which the plant is put; he then fills up the space round it with earth, taking care to spread out the roots, and not to double them up; he finally presses the soil down all round it by hand. The earth should not be trodden down by foot, as the stems of all cinchonas are too delicate to bear the pressure, and care should be taken that there are no hollows on the surface near the plant in which water may lodge. Many of the failures amongst young cinchonas are attributable to deep planting, as some people imagine this protects the plant from the effects of wind. This is a most fatal error, for on no account should earth come in contact with the stem above the collar, this being a most delicate part in young plants. To ensure the hole being filled with earth to the bottom, and that there may be no space at the bottom of the hole where water may lodge and kill the tree, it is well for the cooly to tread the soil into the hole before putting in the plant; it should not, however, be trodden down too firmly. The plants should be carried in the field in baskets, for the less they are touched by the hand the better, and for coolies to carry a number of them in their hands whilst planting is most injurious. A man can put in 400 plants carefully, but no task should be assigned him, as, if hurried, he will probably do careless work.

Ball-planting.

When practicable the plant should be put into the hole with as much earth adhering to the roots as possible, and this should always be done when the nurseries are near the clearing. There are several ways of accomplishing this, the first I shall mention being ball-planting. The plants are here loosened in the nursery, which should be well watered previously, with an alavanga or fork, and taken up with the earth adhering to the roots, which is pressed into a ball round them; they are then carefully placed in large shallow baskets, three feet in diameter and six inches deep, and taken to the field, when they are put in holes with mamoties, care being taken not to disturb the roots. This system, though a good one in the case of coffee, is a very bad one for cinchona, and I would strongly deprecate its employment; for the roots of cinchona plants are far too delicate for such treatment.

A great improvement on this, with but little extra expense, consists in the use of paper cones. These are made out of old newspapers, and resemble the paper bags for sugar used by grocers in England, with this difference, that the small end is left open and not screwed up, and that the sides are gummed or pasted. A cooly with a little practice can make 600 of them per diem, their size being six inches long, by four inches in diameter at the top, and one inch diameter at the bottom. The great advantage of them is that the plants can be taken from the nursery, be put into them at once, and thence be taken to the field; that they decay rapidly when placed in the ground; that the small end being open, the tap-root is not interfered with; and that they keep the earth round the roots, as the plant is being taken from the nursery; not their least recommendation being their economy. Where the plants in a nursery are in even rows, and are all fit to put out, it is a good plan to commence with the row next to one of the small drains, and turn all the plants with the earth adhering to them into it, using the broad end of an alavanga; they can then be taken separately and be placed in cones, with very slight disturbance of the roots. The first row having been disposed of in this manner, the second can be moved into its place, and the third into the place occupied by the second, and so on. Where plants vary in size, the best should be taken out with an English garden trowel, and be put in the cones with as little handling as possible. The plants should then be taken to the field in ordinary baskets, and be put in the holes with pointed sticks, care being taken that no hollow is left at the bottom of the hole. Paper cones.

For the propagation of rare species of cinchona, the use of cow-dung pots is recommended by Mr. MacIvor, who gives diagrams in his "Notes" to shew the way they are made. Their manufacture is very easy and cheap. A set of cubical moulds are first made in a thick piece of planking and cut right through, the bottom being formed by a moveable plank, and to fit into but not fill them, a number of cones are fixed to cubical projections on a board, and so placed as that each shall correspond with one of the cubical moulds. The latter are then filled with cow-dung, and the block with the cones are pressed into them. The pots so formed are expressed by the cubical projections onto the lower moveable board, are dried in the sun, and each becomes the Cow-dung pot.

receptacle for a seedling; a man can make from 1,000 to 1,200 a day, so that their cost is trifling, and when put in the soil, the material of which they are composed forms a valuable source of food for the plant. An improvement on these has been made by a Ceylon planter. The mixture is made up of equal parts of cow-dung, dried moss, and finely powdered charcoal; seedlings pricked out into these are said to come on well; and they can be planted out in almost any weather.

Transplanters. I can also strongly recommend the use of the "transplanter" invented and patented by Mr. Forbes Laurie. These are pieces of tin or zinc bent round so as to form a hollow cylinder, and kept in that position by an iron pin, which, on being withdrawn, allows the edges of the tin to separate about half an inch from one another. It is used in this way; the closed cylinder is forced into the soil of the nursery, so as to have the plant to be removed in its centre; it is then taken up, the plant and the earth surrounding it coming up with it; these are removed to the clearing and put in a hole, the withdrawal of the pin allows the cylinder to open, when it may be lifted up, and the hole filled in. The advertisement of the invention is as follows:—"It has been used with great success on an estate where 100,000, cinchona plants have been removed, without any appreciable loss, certainly not exceeding two and a half per cent, even when there has been no rain for some days. Upon a new clearing, well drained and prepared for planting, very small plants can be put out by these means with great success . . . . . Nurseries need not be made expressly, for in all experiments hitherto they have been used in nurseries intended for planting in the ordinary way. Plants should be removed in regular order, beginning at one part, and so continuing on to the end of the nursery, of course removing only such plants as can be taken up without interfering with those adjoining, and always selecting the largest. As each plant is removed with the earth around its root, the hole left should be carefully filled with good soil, which will improve the plants remaining. One of the chief advantages derived from its use is regular work on a new clearing for women and boys, a gang of whom can be kept steadily planting up the land as the more heavy work is finished by the men. Very wet weather, when nothing can really be done, should be avoided."

There are three sizes now in use, 3″ transplanters for

large cinchona plants over ten inches high, and 2½″ and 2″ transplanters for all ordinary work.

Men carry	81	2½″	transplanters	on a	wooden tray.
Women	65		,,	,,	,,
Men	56	3″	,,	,,	,,
Women	49		,,	,,	,,

For 100 acres, 1,000 transplanters are necessary, the calculation being ten transplanters per acre. Women and boys put from 220 to 250 plants in the holes by this means. A man supplies 1,500 plants from the nursery in a day, filling up the holes left. Mr. Laurie informs us that 33 coolies (27 women and 6 men), put in 7,000 plants per diem. For a clearing lined 3½ × 3½, with 3,500 plants to the acre, an allowance of Rs. 7·50 per acre should be ample, including cost of transplanters, which will last for an indefinite period. When we consider that the cost of shading, the most expensive work in a new clearing, is saved; that hardly any supplying is necessary; that the plants when in the ground continue growing without a check, and that the work is almost entirely done by women and boys, we need have no hesitation in giving this system a trial.

Mr. Wilton has also patented a transplanter differing from the last in that the tin is not open down one side, the plant being ejected by means of a thrust. This machine appears to have given satisfaction. A third invention is by Mr. Scowen. This is merely a machine for taking the plants out of the nursery and putting them in trays without disturbing the roots. The objections to it would appear to be that unless somewhat clayey the earth will not have sufficient cohesion to remain round the plant, and that a heavy shower *en route* to the field must wash away much of the soil. Recent experience has shewn, I believe, that Messrs. Laurie's and Wiltons transplanters are very serviceable for small plants, but that large plants come on better when put out in the ordinary way; whilst Mr. Scowen's, though useful with some soils, fails in others.

I have mentioned that wooden trays are necessary for carrying the plants to the field. Mr. McIvor gives an illustration of a box for transporting such trays to the field. Three light deal-wood trays are made, two by three feet, and a box to contain them one above the other, the lowest tray resting on the bottom of the box, and the two upper ones being supported on wooden sticks,

run through holes in the side of the box, and removeable at will. A case of this kind will contain 540 cow-dung pots.

In whatever way the cinchonas are planted, they must on no account be put too deep in the earth, as I have before said, for if it is heaped above the collar, or junction of the stem and roots, the growth of the plant is greatly retarded, and it does not gain a firmer hold on the ground, but the very reverse.

An application of rotten maana grass to the soil has been found most beneficial to young plants by one gentleman, and Mr. McIvor recommends it as highly beneficial if well decomposed: if too fresh it might prove injurious.

Shading.

In uncertain weather it is a safe precaution to shade the plants when they are put out; indeed I have found this work advantageous in all circumstances, and absolutely necessary when the plants are put out without transplanters. Ferns afford the best shade, and if partially dried beforehand, they do not shrink and expose the plant. Certain kinds of jungle branches, which do not drop their leaves when withered, are also very suitable; but ferns are no doubt the best. This is a very expensive work, the cost depending greatly on the supplies of ferns, or other covering. Rs. 10 per acre is an average rate for a clearing planted $3\frac{1}{2} \times 3\frac{1}{2}$. Mr. McIvor advises thus on the subject:—"The young plants may be shaded after planting by a cylindrical basket open at both ends, twelve inches in diameter, and fourteen inches long, made out of suitable and plentiful material, one man making from eight to ten such baskets daily; this is found to be an efficient as well as an economical way of protecting the plants, as when they are established the baskets can be removed, and are available for further use. When timber is plentiful on the spot, the plants can be effectually protected with split wood. This rough split wood as a protection and shade for the young plants has been found very suitable, while one man is able to shade from fifty to sixty plants per day." Both these methods would be out of the question with most of us on the score of expense, the split wood method costing Rs. 28 per acre at the outset, besides the cost of subsequent upkeep. Bark is sometimes used for shading, but is not as suitable as ferns or jungle stuff, and is more expensive. If the cinchona is planted amongst coffee, shading is not generally necessary, but each plant should be surrounded by three or four small stakes to

protect it from injury. When the coffee is not drained, it is necessary to cut a semi-circular drain above each plant to protect it from wash.

Supplying.

Very soon after planting the clearing, coolies should be sent over it again to fill up vacancies caused by the death of the plants first put in, and this operation may with benefit be performed twice or thrice during the planting season. The earlier the original planting is done, the more opportunities are afforded for performing this work effectively.

Size of plant.

The plants should neither be too small nor too large when put out, but should be well hardened, and about six or eight inches in height. A smaller size than this is preferred by some planters, who find that seedlings, one and a half to two inches in height, are less liable to injury from wind and sun; the great point is, however, that the plants be well hardened. The best size seems to vary in different localities and climates, local experience being the surest guide.

Self-sown seedlings.

By some it is not considered necessary to plant the land in the ordinary way, but in the case of old cinchona, self-sown seedlings are allowed to take their place; whilst in new land, seed is sown broadcast or at stake, four ounces to the acre being found sufficient. Under the former circumstances the self-sown seedlings will be of various ages, and give a return at a much earlier age than if the clearings were replanted. We can well afford therefore to sacrifice appearance and uniformity, and allow them to take the place of the trees that have been removed. It would appear besides that self-sown seedlings are much more likely to prove successful where previous crops of cinchona have been removed, than plants. Of broadcast sowing and sowing at stake, not much is known, but I am sure the use of plants will always continue the more popular and reliable method. When obtainable, self-sown seedlings from an old cinchona plantation form very good plants to put in a clearing, defective ones being rejected.

Planting distance.

The planting distance depends entirely on the specie cultivated, but whatever system of harvesting the bark is employed, the trees should be put fairly close together. The shade thus afforded has a beneficial effect on the bark in all probability, though this is by no means a certain point, and it keeps the growth of weeds in check, whilst by thinning out trees when the plantation becomes too thick, sufficient may be left growing for the pursuit of any system of cultivation. The trees so thinned out will more than pay for the extra expense entailed by planting close. On the other hand, too close planting is, I believe,

a mistake, as it induces an unhealthy appearance, and undoubtedly checks the growth of the tree. This effect is more marked in the case of *succirubra* than of any other species. For *officinalis* 3½ × 3½, *succirubra* 5 × 5, *pubescens* 4½ × 4½, *calisaya* undetermined as yet, but probably 4½ × 4½, should be sufficiently close in each case. For *officinalis* this distance will be found the right one for a clearing of ordinary growth; where selection is exercised, 3 × 3 would not be too close for the small-leafed variety, whilst 4 × 4, or even wider, would be the distance for the large-leafed variety. For red barks 4 × 4, and for crown barks 3 × 3, are very generally recommended distances, but I think those I have mentioned are sufficiently close for good soil and fair shelter.

In supplying the vacancies caused by plants dying at an early age, patches should never be supplied with cinchona, but other plants, tea for instance, put in instead. As I shall shew later, these patches are attributable to fault in the soil, and to continue supplying them from year to year is a loss of time and money. Where individual trees die the matter is different, as the root of the evil probably lies in the tree itself.

Shade. In India shade of any kind, except when the plants are quite young, is very injurious to all cinchonas, and induces a lanky spindly growth; the drip from overhanging trees also constantly proving fatal. Mr. McIvor writes as follows on the subject:—"The system of cultivating the cinchonas in partially cleared land is liable to this objection, for the forest trees when deprived of a portion of the support upon which they are accustomed to lean are also liable to be blown down; and, moreover, this system has the more serious objection of shading the plants too much from the sun, while they are subjected to the damaging effects of the drip during the rains, and the roots of the forest trees immediately fill up and choke the holes into which cinchonas are placed, thus depriving the young plants of nourishment. In forming our plantations, we have planted a considerable extent of land in this way, but with such bad results as now render it necessary to clear away the remaining forest trees. Our principal plantations have been formed in land entirely cleared of forest, and here the growth of the plants has been incomparably more satisfactory than that of those placed under any degree of living shade. It is therefore certain that the open system of planting will be the only successful one, especially on

the Neilgherries; it is true that while the plants are young this system has disadvantages which should not be overlooked. I refer to the excessive evaporation and radiation during the bright and cloudless season, when our dry and cold weather prevails. We have hitherto combated this difficulty by sheltering the young plants with a temporary shading of bamboo or fern. Many thousands of our plants, however, have passed through successive dry seasons without any protection whatever; and, although their growth has not been so rapid during the cold weather, their health is quite equal, if not superior, to any of those protected by artificial shade, while during the spring and rainy season the growth is more rapid in the plants without shade, than in those which have been shaded; consequently the system of artificial shading may be abandoned altogether, except in very exposed situations, and when the plants are newly transplanted." In several districts in Ceylon shade-planting has been tried, and where the climate is dry with success so far. The trees are of somewhat lanky growth, and the bark is thin, but the percentage of deaths is less than in the open, and probably the shade is beneficial to the bark.

The best conditions for growth are those ensured by a fairly closely planted clearing, namely, abundance of light and air to the upper branches and leaves, with shade to the stem, such trees being the richest in alkaloids, those with spare foliage being comparatively poor. The shade which is advantageous to cinchonas is, therefore, that which is supplied by the neighbouring trees growing at the same time, and which is more effectual, the closer the trees are planted, up to a certain point. In wet districts, shade planting appears to be a failure from drip.

Break-winds.

The importance of leaving belts for protection against wind on all ridges, and wherever they are likely to be of service, cannot be overestimated, a little judgment and care in this matter, exercised at first, may increase the value of the clearing greatly. Planting cinchona under the shade of such belts has been tried, but there is considerable danger of lessening the effectiveness of the break-wind and exposing the forest trees themselves to injury, if all the undergrowth is cleared away. The safest plan is to clear and plant about half the belt only, on the protected side, leaving the undergrowth on the windward side intact. Where gum trees

are planted for this purpose, cinchonas are said to grow well under their shade. With regard to artificial break-winds, it is much preferable to leave the natural forest standing where possible, than to trust to the growth of trees which are themselves liable to the same injury, from which we want to protect the cinchonas. There are, however, certain disadvantages inseparable from natural belts, amongst which is the shelter afforded by the undergrowth to noxious weeds and animals, whilst the trees composing them have an inferior value as timber. Rows of blue gums and black acacias at short intervals along windy faces appear to answer admirably as break-winds, the cinchona between them growing well; and if natural belts be left on the most exposed ridges, and wherever they are likely to be a protection to areas of some extent, the greatest amount of protection will be afforded.

CHAPTER IX.—NURSERIES.

The two principal methods of propagating cinchonas are by seed and by cuttings. There are other ways which we will consider later, but these are the methods most commonly employed, and which should first engage our attention.

Disadvantage of seed.

The chief objection to propagation by seed is the liability of the finer species to sport; the *calisayas* especially, and the varieties of *officinalis* in a lesser degree; it therefore becomes necessary in perpetuating valuable species to resort to cuttings, in order to attain a fair amount of certainty as to the value of the resulting plants. For the propagation of the ordinary species, seed is most commonly employed from the many obvious advantages it possesses, which render its use so much easier, and more convenient.

Healthiness of cuttings.

There is a large difference of opinion in Ceylon on the subject of the healthiness of trees raised from cuttings, but all Indian authorities agree in considering that trees from cuttings are quite as healthy as those from seed. The balance of the evidence in Ceylon is certainly in their favour, provided the proper wood has been used; what this is I shall shew later. There can be no doubt however, that having no tap-root, they are more liable to injury by wind; and one gentleman, who is strongly in their favour, advances this fact as being an advantage: having no tap-root, they are less liable to "strike water and produce wet feet." Personally I have found trees

originally from suckers grow perfectly well, and shew no signs of decay, but I have found them less able to stand unfavourable planting weather than seedlings in some cases. They also shew a tendency to die off during the first year on the occurrence of any abnormally wet or dry weather, and a large percentage are generally lost in this way. In spite of this, however, it will be found that in practice a few beds of cuttings obtained from the numerous suckers always to be found on old cinchona trees, are a most welcome addition to one's stock of plants for the year. Another objection raised against them is that they have a tendency to blossom and seed at an early age. I can only say that my experience has been the very reverse of this, and cannot but think that the trees in question were forced into the blossom which generally precedes death, from some cause or other probably quite external to the plant itself. Tendency to blossom, dying trees apart, is greatly affected by elevation; trees at a low elevation seeding at an earlier age than those higher up.

There is said to be considerable difficulty in raising *calisayas* from cuttings, the shoots from coppiced trees alone being generally successful. In Ceylon, however, *calisayas* have, in some instances been found no more difficult of propagation in the ordinary way than other species. *Officinalis* is by no means readily propagated by cuttings, but in the case of *succirubra*, a very large percentage will be found to succeed.

Seed.

When practicable, care should be exercised in selecting the trees from which seed or cuttings are taken, that the parent trees are the best of their kind available, and that they be of mature age. I have found Indian seed fairly dependable in this respect, but by no means equal to the carefully gathered seed which can be obtained locally. In gathering seed, it is of the utmost importance that it should be thoroughly ripe, as immature seed is the root of many failures in nurseries, and produces weakly plants even if it germinates. There are several ways of collecting the seeds, the best being to shake the trees on which the seed vessels are bursting over mats placed on the ground. Another method is to tie the ends of the seed-bearing branches in muslin bags; or the ripe seed vessels may be gathered by coolies, and laid out to dry until the seeds fall out of their own accord, in a place exposed to a free current of air. The first two methods are the best, as

they do not allow of the possibility of immature seed being gathered.

Where a tree is bearing a large quantity of seed, it tends greatly to improve its quality to thin out a certain proportion when green, and only to leave on as much as can be thoroughly matured. It will be noticed, too, that dying trees, though of no age or size to speak of, always flower and bear seed, which should be destroyed.

Mr. McIvor calculates that an ounce of clean seeds produces on an average from 20,000 to 25,000 plants. Generally speaking we find this too high an estimate by far, though in one case I have heard of 1 lb. *succirubra* seed giving 350,000 plants. 100,000 plants per lb. from *succirubra*, and 70,000 from *officinalis*, are the results that it is safe to calculate upon when the seed comes from a distance, and is not perfectly fresh. This calculation will probably be exceeded, and it will allow for a percentage of failures. For *calisaya*, 2 ozs. seed have given 40,000 plants. This seed was no doubt unusually fresh and good, and it would not be safe to rely on such satisfactory results.

The sooner the seed is sown in the nursery after the gathering the better, as if kept long it loses its vitality. For transport to a distance it should be packed in porous cloth, and sent by post.

Rs. 4 per lb. is charged for seed from the Indian Government gardens, with R1 extra for packing and postage. This price is so low, that it is hardly possible that the seed can be selected with the necessary care; which accounts for the very great superiority of carefully gathered Ceylon seed over that from India.

Transport of cuttings.

By careful packing, cuttings can be sent for long distances without losing their vitality, the method recommended by Mr. Burbidge in his "cultivated plants" is as follows:—"A British correspondent of the *English Mechanic* remarks that the primitive Hindoo was the first discoverer of the proper packing of tender cuttings, and to his instinctive simplicity he was heavily indebted for a large portion of the floral treasures he collected, and had the pleasure of transmitting during his long sojourn in the East and other quarters. The following is a description of the process. Having tied your various cuttings up in lots, and all of as nearly the same length as possible, proceed to cut down that very ubiquitous tree the banana. Say your cuttings are 18 inches long, you will require a case of two feet; therefore chop off

a thick portion of the above length, and next with your axe split it lengthways and remove the fleshy bark, set like the coats of an onion, layer upon layer. Within this case you pack your cuttings rather loosely, in slightly moist moss to prevent their heating, securing the two halves of the banana stem with ties of bark or twine; then you can make a stopper for each end of same substance, and dipping the first in moist clay, drive them in, and cut them off quite even with your box. The packages should then be sewn up in stout wax-cloth, bearing the direction, destination, &c. In some cases a thick piece of green bamboo is preferable to the banana as a case for cuttings, and the following methods or modifications of the process just described will be useful in particular cases:—1. The bundle of cuttings, being packed air-tight and water-tight in sheet India-rubber, is immersed in the ship's water-tank. 2. Packed similarly, they are stowed in a ship's ice-room. 3. Enwrapped in several folds of wax-cloth, and then dipped several times in a liquefied mixture of soap and wax till densely covered; these many coats may afterward be pressed by the hand into a dense mass." To quote further:—"Wherever healthy seeds rot instead of germinating, in nine cases out of ten excess of moisture in the soil, or irregular application of heat and moisture, has caused such a result; and it may be taken as a rule, that the smaller and more delicate the seed sown, the less moisture is essential in the soil in or on which they are so placed. In the case of old or unhealthy seeds, the best plan is to sow them in dry soil, placing them afterwards in a genial heat and moderately humid atmosphere, where they should not be watered until signs of germination appear. In this way the seeds are gradually supplied with moisture by the powers of absorption or attraction, possessed by all soils in proportion to their dryness when placed in the moisture laden air; and this plan will be found to succeed when any other fails."

The most suitable place for a nursery is a piece of virgin forest land, the soil of which is light, with plenty of vegetable mould, and with running water close to it, above it if possible, so that it can be conducted to the spot in a drain; perfectly flat land should be avoided, and a place chosen with a slight slope, as the drainage of this is much better. As cinchona seeds germinate best at a temperature between 65° and 75° F, and will not sustain a temperature higher than 80° F, according Site.

to McIvor, nurseries should not be made at too low an elevation.

Making nurseries.

In preparing the nursery, all roots and stones should be removed, and as many of the stumps taken out as possible; the ground should then be dug over, and beds formed twelve feet long, and four feet wide, the length being up and down hill, by cutting trenches eighteen inches wide and deep, and throwing the earth on the beds at each side, which should then be carefully smoothed. The length of the beds is not of much importance, but they should not be wider than four feet, otherwise there will be a difficulty in weeding them. In order to promote drainage, it is an excellent plan to make a foundation of stones, one layer is sufficient, and construct the beds on the top of this. After the beds are thus made they should be carefully barrelled, so that the centre is at least six inches higher than the sides, and a layer of sifted vegetable mould, mixed with sand, should be spread over the top to the depth of two or three inches, and carefully pressed down with the hand so that it shall be of uniform firmness all over; it should not be hard and compressed, but firm and even. The seed should then be scattered pretty thickly over the surface, and a sprinkling of fine earth, sand, or powdered moss put over it; this is merely to keep the seed in position, and bring it into close contact with the soil, and to do which more effectually, the whole surface of the bed should be gently pressed with a board. Another plan is to mix the seed thoroughly with finely sifted earth or moss, before spreading it over the beds.

McIvor's recommendation

Mr. McIvor recommends the steeping of the seed in water before sowing, if they are fresh for twelve hours, if they have been kept for some time for six hours. They should be put in a bag and immersed in water, and when taken out will be found to have swollen considerably. To separate them they are mixed with twice their bulk of dry sand, gently stirred till they separate and intermix with the sand, and then sown on the surface of the soil. He also recommends the mixture of four times its bulk of sand with the vegetable mould to promote drainage, and that the latter should be exposed to the sun for two or three days, and then heated to about boiling point, in order to destroy grubs and larvæ of insects; after being allowed to cool, it should be moistened before being put on the beds. This

is a most excellent precaution, and were it more frequently taken, there would be fewer failures in nurseries fron insect and fungoid pests.

Watering should be done very carefully, an excess being especially avoided, the object being to maintain an uniform state of moisture. It should be done in the early part of the day, the temperature of the water being brought as nearly to that of the air as possible, by letting it stand for a short time in the sun for instance when too cold. A finely bored garden syringe should be used, a stream of water being forced through it at some distance from the bed, so that it shall fall in the form of spray. In dry weather it is necessary to water the beds more than once during the day, but it should not be done in the evening. Watering.

A most excellent plan has been devised by Mr. Moens for the germination of seed of special value, and I cannot do better than let "Viator," a correspondent of the *Ceylon Observer*, describe it in his own words:— Moen's system of germination.

"He had noticed that one fruitful source of the loss of individual seeds was their constant displacement. The seeds of the cinchona tree are so light that, however finely perforated is the rose of the watering-pot used to water them, they are sure to be pushed about by the force of the water, and in many places heaped one upon another and destroyed.

"To remedy this he bethought himself of watering from below by absorption instead of from above in the usual way.

"A large number of chatties are prepared, these chatties being rendered more than usually porous by being only half baked. The chatties are in size 18 in. × 12 in., and having been filled with powdered earth, are ready for the reception of 1,000 cinchona seeds, placed at equal distances in circles, gradually diminishing till a single seed occupies the place of honour in the middle. All these seeds come up in the exact places allotted to them, the only failures being from those seeds which are naturally barren, and the seeds which are naturally barren form an exceedingly small percentage of the produce of a vigorous parent tree."

"Morning and evening the pots are placed each in a saucer of water, or else in rows in a long trough containing enough water to cover the pots half-way up their sides. The soil soon becomes perfectly moist, and then the pots are taken out of the water again. These pots

or chatties are kept in houses like rough conservatories. There are plenty of coarse glass tiles in Java, and these make a capital roofing for the seed-houses, let in here and there with the ordinary tiles of baked clay."

"The temperature of these seed-houses varies between 59° and 71°."

Shade for beds.

It is always necessary to provide shade for seed-beds, an ordinary thatched roof with hip ends over each bed being the simplest form. The object being to admit plenty of light and air, and allow room for watering and other operations, without exposing the seed-beds to rain or sun, the lowest point of the roof should be about two feet six inches above the level of the soil; moveable mats being provided to shut out sun and rain when necessary. When thatch is not near at hand, cadjans or talipots will make an efficient covering, but in some cases, where the nursery is intended to be a permanency, a roof of jungle shingles or weather-boarding is the cheapest in the end. In dry climates, a simple shading of ferns stuck in pretty thickly over the seed-beds has been found fairly successful, whilst a layer of grass pegged down onto the soil to prevent stirring by the wind, and replaced by ferns on the germination of the seed, has had a thorough success. Though much seed is doubtless wasted, yet the method is a cheap one, and the plants so raised are very hardy. Another plan is to scatter the seed, mixed with soil, round the stems of coffee trees, and thin out the resulting seedlings into similar situations.

In from two to six weeks, according to the climate, the seeds will germinate, when very great attention must be observed that a state of moisture with a sufficiency of light and air is maintained, otherwise the seedlings will die off in patches.

Pricking out.

The next operation is to prick out the seedlings into nursery beds. Dr. King advises two prickings out, the first from the seed-beds into nursery beds or pots, and a second when the plants attain a height of four inches. In Ceylon we find the one pricking out sufficient, and that in lieu of a second, it is better to put the plants straight into the clearing when they attain the size mentioned.

The pricking out should be done when the seedlings have two or three pairs of leaves, men going over the whole nursery from time to time, and taking out those that are sufficiently large for transplanting, which

thinning causes the seedlings left in the seed-bed to grow more rapidly, and allows space for seed which has been lying dormant to germinate. The seedlings should be removed very carefully, after being loosened with a flat pointed stick, so that as few of the tender rootlets are broken as possible. In removing the seedling, and in replanting it, it is of the utmost importance that the coolies do not touch the rootlets ; they should be made to hold them by the leaves only. The seedlings so taken out should be transplanted to nursery beds, formed in the same way as the seed-beds, but with a thicker layer of vegetable mould and sand, and put in lines two inches apart. We have been told that elsewhere they are put 5 and 6 inches apart, and allowed to attain a height of a foot or more before being planted out. Such distances would be impossible with the large nurseries we have in Ceylon, and quite unnecessary for the size of plants we put out. Whether this close planting is a cause of disease in nurseries is another point, which is very doubtful, but even if it were proved to be so, we could not afford to give much space to each plant. Where the plants are to be grown in poor or exhausted soil, it is a mistake to prick them out into beds of rich mould. If the layer of vegetable mould is mixed up with the funder-lying soil, thus rendering the whole more of the nature of the future site of the plants, their growth after being planted out will be found more satisfactory ; though growing slowly, perhaps, in the nursery, they will be better able to withstand the removal into inferior soil. This is not merely a theory, but will be found practically true.

Before removing the plants from the seed-bed, it should be well watered, so that as much earth may adhere to their roots as possible, and the nursery bed that is to receive them should also be watered. The best way to put the seedlings in with regularity is to mark the bed with a string from side to side at intervals of two inches, and put the seedlings in these lines at proper intervals. Another way which ensures greater regularity, but is not so simple, is to have an oblong plank two feet by three, with rows of pegs along it sufficiently large to make holes to contain the roots of the seedlings, which being pressed on the surface of the beds, will effect a considerable saving of time, and form a sure index of the number of seedlings put into each bed. When being put into the holes,—which the coolies should make of the right size with their fingers, and not with sticks, the latter

being always too deep,—great care should be taken that the rootlets have plenty of room, and are not doubled up, and the soil should be pressed down so as to fill up the hole thoroughly to the bottom, and not leave a space there. In this case also it is very important that the seedlings are not put in too deep, covering the collar, a fruitful source of failure. For purposes of transport, it is often advantageous to transplant the seedlings into shallow boxes filled with earth. A cooly can put in from 1,000 to 1,500 seedlings according to their size. Beds 4 feet wide and 20 feet long will contain 2,880 plants, two inches apart.

Shade for beds. Artificial shade is always necessary for the beds, but it should give freer access to light and air than in the case of seed-beds. There are two methods of covering nursery beds, by roofs, and by ferns or jungle stuff; in the former case, they should run east and west, in the latter their direction is of no consequence, straight up and down hill being the simplest and least liable to damage. When thatched coverings are placed over nursery beds, their shape should be different to those over seed-beds; they should rise from near the level of the bed on the south side, to above the north side of the bed, with a single slope, sufficient to carry off all rain. The side thus left open should be protected with mats where it affords access to the sun or rain. Other materials than thatch may be used as a covering, talipots or cadjans amongst them, but as the area covered by the plants is large when two inches apart, economy must be studied in the matter. I have found a covering consisting of pliant sticks three feet apart, bent over the bed in the form of an arch, and with the points in the ground on either side, supporting a single thickness of coir matting, a very efficient shading. It does not allow too much moisture to penetrate, and affords access to a sufficiency of light and air. It is also very cheap, as old store matting, useless for other purposes, can be employed for this. Another plan which is generally found successful is to shade the plants with ferns, or jungle branches which do not drop their leaves, stuck in the ground between them. In this case one danger is from accumulations of moisture about the stems of the ferns, in spaces caused by their shrinking, or by their being shaken by the wind, which kill the plants in proximity to them. Careful attention will however obviate this. In dry weather, the most satisfactory system will be found

to be a shading of ferns; in wet weather, particularly at high elevations, this will not answer, and a roof of some kind is necessary. Much of the success of the fern system depends on the care with which they are pruned before being put in the ground. The bottom twelve inches should be freed of all leaves, so that six inches being put in the ground, there will be a clear space of six inches around the plants for the free circulation of air, while one pair of leaves is sufficient on each fern, so that in fact each may be cut into several sections for use.

For some time before the final transplanting to the clearing, the plants should be hardened by a gradual exposure to the sun; this is done by removing a small portion of shading material at a time until all is gone, when they should remain for a few weeks thus exposed before they are disturbed. If this is not done they remain delicate, and any sudden exposure kills them.

Season.

From the sowing of the seed to the final planting, some eight months or more generally elapses. During the whole of this time judicious watering should be carried on whenever the beds are dry. The best time for planting seed for the S. W. monsoon is during the wet season, August and September, so that the pricking out shall take place in the dry weather; it is then only necessary to shade the plants with ferns or jungle stuff, a great saving of expense being the result.

Diseases.

The number of seedlings in nurseries that die off every year must be something enormous; were it not for this there would hardly be space up-country for the product of all the seed introduced from India and elsewhere, and produced in the island. This dying off is generally occasioned by an excess of moisture, exposure of a portion of the bed to the sun's rays, or some similar cause, which a little observation will indicate in each instance; it is a curious fact that the first attempts at a nursery are seldom successful, and it is often necessary to repeat the attempt many times before success is secured. In many cases, however, the seedlings are found to die off in patches when damp, or the other causes mentioned apparently cannot be the reason. In one instance I have been able to trace this dying off to its true cause. In a large nursery, some individual beds into which seedlings were transplanted were effected in this way, the plants dying off in patches, which began

to spread rapidly. On enquiry it appeared that the surface soil of these contained a large proportion of rotten stable manure, taken from an old heap close at hand, and which the coolies had mixed with the jungle soil, and put on a few of the beds. The surviving plants being taken up and put into other beds, became quite healthy and grew well. In this case the cause undoubtedly was extreme richness of soil. As I have stated before, Mr. McIvor found that the greatest success in the germination of seed, and the raising of seedlings, was attained by putting them in a mixture composed of leaf-mould, or the earth produced by rotten leaves, sifted, and mixed with four times its own volume of sand. Were these directions more generally carried out, and our minds disabused of the notion that rich vegetable mould alone is the best thing for cinchona seedlings, we should be less troubled by failure. Besides the extreme richness of such soil, it is to a great extent retentive of moisture, and unless mixed with sand to decrease this property, is too much so for the health of the plants. Another fruitful source of disease, particularly where ferns are employed, is the baring of the roots of the seedlings through sinking of the soil on the beds. Heavy rain sometimes increases the evil, but it constantly occurs without this, and the result of this exposure is to weaken and frequently to kill the plants. A fresh layer of soil is the simple remedy, close attention preventing the evil from ever becoming great.

Another cause of failure is the state of darkness that some nurseries are kept in, and the idea that light and air should be shut out. A free circulation of air, especially in a damp climate, or during wet weather, is absolutely necessary to prevent the plants damping off.

Much of the success of nurseries depends on the climate. In some districts, especially on the Uva side, success is comparatively easy. For though all are subject to the attacks of insects, the wholesale dying off, which has disappointed so many hopes, is comparatively speaking rare in dry climates.

Insects.

Of the insect pests, the most common is perhaps the black grub, which in nurseries, as in planted clearings, is very destructive to the seedlings by nipping them off just above the ground. There is another grub that eats the roots of the seedling, besides various beetles, crickets, &c., which confine their ravages to above ground. It is very difficult to get rid of these pests, but perhaps a dusting with lime is the most effectual plan. Mr.

McIvor's method of ridding the soil of the eggs and larvæ of insects, and of the spores of fungi by heating it, is one to which very little attention is shewn. Were it more generally attended to, we should hear fewer complaints of the attacks of insect pests.

The weeding of a nursery is sometimes a very troublesome matter when it is made on old ground. The difficulty is very greatly increased when the plants are shaded by ferns, as it is difficult to pull up the weeds without disturbing them ; it can be done, however. The weeds should never be allowed to attain any size, as they choke the seedlings, and hinder their growth. Weeding.

In Sikkim, the seed-beds are sometimes infested by the mycelium of a minute fungus, which kills many of the seedlings, but I have not observed this in Ceylon, though some have. A gentle stirring of the soil is said to prove beneficial.

Whatever the evil may be that attacks nursery plants, it is as a general rule irremediable. In this case especially "prevention is better than cure," and though the best nurseries are liable to attacks of various kinds, still it will be found that those which are carefully and judiciously made and looked after from the first, will be liable to but a tithe of the evils that beset those less fortunately circumstanced.

A gentleman suggests a system by which the expense of pricking out may be saved. Make the beds as usual of jungle soil, spread over them a dressing of sand and mould a quarter of an inch thick, in the proportion of three of mould to one of sand. Over this place a dressing of very fine sifted river sand. The beds are now ready for receiving the seed, which has to be mixed thoroughly with 40 times its bulk of sifted earth in the following way.

First mix a tumblerful of earth with the same amount of seed thoroughly, then add 39 tumblers full of earth, mixing each one intimately with the mixture of earth and seed previously made, until the two are well blended in the proportion of 40 to 1. This mixture is then to be very thinly scattered over the beds, the coating of sand making it easy to see when this is done. It is maintained that by this means the plants will be so thinly scattered as to have room to grow until they are put out in the field. The plant must have a certain fixed space to grow in, and in this case the whole surface occupied by them has to be as carefully sheltered and

attended to as an ordinary seed-bed; the expense thus incurred will therefore bear no proportion to the trifling item of pricking out, when a large area of the nursery merely requires a shading of ferns.

Several systems of putting out seed in the clearings have been tried, either behind rocks and stumps, or in the holes that the plants are to occupy permanently, but the great waste of seed that is inevitable in these cases render them unadvisable.

Cuttings.

The best wood for cuttings is that of the current year's growth, from shoots on the lower part of the stem. The ends of branches will also do, but they are not nearly as suitable as "suckers." When too large and succulent, or when the pith has formed, the cuttings generally die off; and I generally direct all that are thicker than a pencil to be rejected, when there is no lack of materials, for open air planting. The shoot after being taken from the tree should be cut in a sloping direction with a sharp knife, just below a joint, from four to six inches from the top. All large leaves up the stem should be broken off, but the pair at the top if only half developed should be left, if fully developed, the petioles and a portion of the leaf only should be left. The upper portion only of each shoot should be planted, for though the other portions of the stem would grow, they do not appear to produce such healthy plants.

The cuttings should be put into shaded beds as described before, and in all ways be treated like seedlings, though when they have once struck far less care is needed. As they are very liable to rot off at the level of the soil, a layer of sand on the mould to promote drainage is of great use. When put in unshaded beds in wet weather, a large proportion will grow, but the greatest amount of success is attained when the beds are shaded; and for this purpose, ferns are as effectual as with seedlings. Succirubra is very easily propagated in this way, the cuttings forming roots in two or three months, but as they never lose the appearance of vitality from the time they are put in, they are often supposed to have struck before they really have. The other species are, unfortunately, much less easily raised from cuttings, and would appear to require bottom heat. It is very important that the cuttings should not be transplanted until they are well rooted. If they are moved before their roots are thoroughly hardened, they invariably die off.

Mr. McIvor recommends that the cut end should rest on a piece of dry brick, or in brick dust, so that the juice which flows from the cut may be absorbed, and not cause mildew and rot, as is frequently the case; his system being to put a layer of brick dust, about an inch in thickness, above the soil, and insert the cuttings in it. Sand used in the same way has been found a success. Brick dust.

The employment of artificial heat is a means of forcing the cuttings to root more quickly, and for this glass-covered frames are very useful, the cuttings being put into pots or boxes which can be moved about. These frames are unfortunately very expensive in Ceylon, but for the propagation of valuable species of cinchonas, artificial heat is a necessary adjunct, and a little expenditure soon amply repays itself. Before entering on the consideration of this part of the subject, I will give an extract bearing on it from Dr. Lindley's "Theory and practice of horticulture," which is quoted by Dr. King. "It is known that plants possess some quality analogous to animal irritability, to which, for want of a better, the name of excitability has been given. In proportion to the amount of excitability in a given plant, is the power which its cuttings possess of striking. The great promoter of vegetable excitability is heat. Therefore the more heat a given plant has been exposed to, within certain limits, the more readily its cuttings strike root. This explains what seems to have puzzled Mr. Newman. 'The young wood,' he says, 'of trees growing in the open air will not do for cuttings: and yet if these same trees are forced in a hot-house, their cuttings are almost sure to succeed.'" Again:— Artificial heat.

"What is demanded when cuttings of plants are to be struck is a due adjustment of heat, light, and moisture. The first stimulates the vital process, the second causes the formation of matter out of which roots and leaves are organized, the third is at once the vehicle for the food required by the cuttings and a part of it. The difficulty is to know how to adjust these agents. If the heat is too great, organs are formed faster than they can be solidified; if too low, decay comes on before the reproductive forces can be put in action. When light is too powerful, the fluid contents of the cuttings are lost faster than they can be supplied; when too feeble, there is not a sufficiently quick formation of organizable matter to construct the new roots and leaves with.

If water is deficient the cutting is starved; if over-abundant, it rots."

Glass frames.

Bearing these principles in mind, Dr. King tells us that "care should be taken to provide mats to lay on the glazed frames, so as to shade them when the sun's rays are too powerful; an equable moist atmosphere should be kept up inside the frame; ventilation should be provided for by opening the frames for half-an-hour or an hour early in the morning, and by keeping them at other times slightly ajar by means of a small stone or stick; and above all, watering should be very carefully done, by means of a finely drilled syringe. Deluging should always be avoided, and the leaves should never be allowed to be wet in the evening or at night."

Propagating houses.

The best form of bottom heat is that supplied by means of a flue of hot air or water, which runs beneath the soil in which the plants are growing, but the great difficulty is to get sufficient care bestowed on the furnace to keep the soil at the uniform temperature required. Mr. McIvor in his notes gives a plan of a propagating house, costing Rs. 800 to Rs. 1,000, to construct, which consists of a potting house and furnace room at one end, from which a flue is conducted under a row of propagating frames, fifteen in number. These frames are about three feet square, and contain 1,200 cuttings each, or in all say 18,000. But the rapidity with which they strike,—the majority of them being invariably rooted within the month,—makes it possible to have numerous relays during the year. I may mention incidentally that the cost of this building in the Nilgiris was Rs. 2,100, but apparently more was spent than was necessary, and it could no doubt be erected in Ceylon for half the amount.

The cuttings for this purpose should be from the young tender shoots, not more than two or three weeks old; they are put into pots in the way previously described, and plunged in beds of deep sand with which the frames are filled. The bottom heat should not exceed 75° Fahr.

It is possible that an invention by which acetate of lead is used for heating foot warmers might be used for nursery purposes. This substance has considerable latent heat; dissolving at a certain temperature; it thus absorbs a large quantity of heat, which becomes sensible during re-crystallization in cooling. Any expedient of

this kind, which would do away with the necessity for furnaces with all their attendant risks, would be of value.

For the propagation of trees of special individual value, resort should be had to the methods of layering and grafting, which I will now describe.

Layering.

When it becomes desirable to obtain cuttings by artificial methods, the operation of layering must first be resorted to for the production of stock plants. This consists in bending down the branch of a tree, or if young, the whole stem, to the ground, and half cutting it through at the bend, so that roots may be thrown out from the cut when it is put in the soil. In the case of *calisaya* the bending must be done very carefully, as the wood is brittle, and therefore it often becomes necessary to elevate the soil to the branch in boxes resting on posts. The cut part being put into the soil should be pegged down if necessary, and sand put round it to promote drainage. As the juice of the plant is found to flow too freely from the wound, a piece of perfectly dry brick must be inserted to absorb it and prevent mildew and rot. This is McIvor's recommendation, but no doubt as in the case of cuttings, a layer of brick-dust or sand is equally effectual. In the case of branches from a tree being layered, it is necessary to obstruct the channels by which the sap would return to the stem, and thus to secure it for the layer, to do which the branch should be well bent back before being put into the ground. *Calisaya* layers are found to root in three or four months, during which time they must be carefully watered. When well rooted the layers become "stock plants," and should be detached and transported to propagating frames. A crop of cuttings may be gathered from these every month or two. Young plants may be layered in the same way when they attain a height of ten to fifteen inches. In taking cuttings from the stock plants the cutting should be three or four inches long when taken, and should leave a bud or two on the part left for the production of new shoots, the whole shoot on no account being taken. The cuttings so obtained should be treated as previously described.

Buds.

Propagation by "buds" is a method that was adopted at the beginning of the cinchona experiment, but is now superseded by those previously described. As, however, it has the advantage of producing a large number of plants, I will briefly describe it. An ordinary

cutting is taken, and severed on both sides of a joint; the stem is then split down the centre so as to leave a leaf and bud intact, and immediately placed upon a piece of brick, or in the brick dust in the pot; the bud itself being covered with about a quarter of an inch of soil, while the leaf of course projects above the surface. The whole secret of success then depends on the amount of moisture given; if this is supplied in excess, they rot immediately, even in a day; but if sufficient care is exercised, the losses will not exceed three or four per cent. For the description of this and the process of layering, I am indebted to the works of McIvor and Dr. King.

Grafting. Grafting is a more difficult operation than the preceding, and in general consists in the combination of root and branch cuttings, with the object of obtaining as rapidly as possible a fruit-bearing tree, from which seedlings can be grown. This system has been largely pursued by Mr. Moens in Java for the multiplication of ledgerianas, with great success. For a description of the method we are indebted to "Viator" and Mr. Kay-Shuttleworth, who visited Java, and there saw the operation performed. Succirubra being the commonest and most rapid growing cinchona, is chosen for the stock. Succirubra plants about a year old are chosen, and to economise space are stumped at a point six or eight inches above the soil. This is done just above a joint. A flat cut is then made in the stem under the bark, which is not removed, sufficiently deep to make a surface large enough to allow a ledgeriana shoot (cut through diagonally, the cut being one to one and a half inches long), to fit cambium to cambium to the succirubra, the bark of the succirubra overlying the cut being left intact. The ledgeriana shoot must be cut just where the hard mature wood ends, and where the branch begins to be tender and succulent from the newness of its growth; it is then fitted carefully into the cut in the succirubra stem, the flap of bark put over it, and the whole bound firmly with Berlin wool. String pulled out of an ordinary sack will do almost equally well. The operation is simpler if the succirubra has a double stem, one of which is then cut off diagonally at the fork, leaving a flap of bark at the upper end of the cut, the ledgeriana shoot is then cut, so that it shall correspond in shape and size with the cut surface of the succirubra, but a flap of bark is left hanging from its lower end. The two cut surfaces are then fitted together, the flap of ledger bark

overlying the succirubra stem, and the flap in the succirubra overlying the ledger cutting, and thus giving a better hold to the binding. The pots which contain the grafted plants are then laid on their sides, graft uppermost, in propagating frames, and kept until the bark begins to unite, and new leaves to shew when they are placed upright. The succirubra is cut off just above the graft as soon as the plants are fairly united, and there is no fear of this further mutilation of the tree injuring the young graft, the bandage being removed at the same time. Four weeks is the time that generally elapses before this can be done. It has been proved that a good graft grows faster than an original ledgeriana tree, and that the qualities of the stock never in the slightest degree affect the tree it bears.

A skilled labourer can graft from 200 to 250 ledger cuttings on succirubra stems every day, and the operation is therefore evidently not a very expensive one. There can be no doubt as to its advisability in all cases where individual trees of special value are to be propagated from.

Mr. McIvor's hints on packing and conveying plants in wardian cases are of value, and I will therefore quote them:—"Wardian cases can be procured here at a cost of Rs. 15 each. One case will contain from 170 to 220 plants according to the species, instead of 28 or 30 plants as formerly. In the system of packing, which is now recommended, the Wardian cases are filled with moss instead of earth, to a depth of about six inches, and the cinchona plants in the pots in which they were grown, are firmly packed in the moss, and secured with cross battens, in order to prevent their being displaced, should the cases be upset in transit. When the plants are thus secured, they receive a moderate amount of water; the sashes are then screwed on, the glass being protected by battens and secured from the direct rays of the sun by a covering of thin cloth, so as to admit a portion of light. In this way the plants can safely be conveyed to Calcutta or Ceylon without the cases being opened; but when the journey is likely to be prolonged over a month, the cases should be opened morning and evening, so as to admit of the plants receiving light and air, water being added only when the surface of the earth in the pots is dry. Upon receipt of plants in Wardian cases it is desirable to place them, in the first instance, under the protection of glass. If this be not available, Wardian cases.

the cases should be placed in a shady position, and opened only so much at a time as the plants will bear without flagging. So soon as the leaves of the plants are observed to flag or droop, the cases should be immediately closed, and great care taken not to give the plants too much water at the roots, as this is apt to cause them to rot; in fact, the soil at the roots should always be kept rather dry than otherwise; the supply of moisture being kept up in the plant by frequently sprinkling the leaves. This treatment is only necessary until the roots assume a healthy and vigorous action, which will take place in from eight to twenty days, according to the length of time the plants have been confined in the Wardian cases."

CHAPTER X.—LOPPING.

Lopping for wind.

In all wind-blown situations,—and there are few cinchona plantations in Ceylon which do not get a fair amount of wind in places at one time of the year,—it is a wise precaution to lop off the lower branches of the plants every year, until the stem is firmly rooted in the ground, before the wind commences, leaving only two pairs of branches at the top. The trees so pruned offer but little resistance to the wind, and are consequently not shaken so severely by it, whilst they rapidly develop branches as they grow after the wind ceases. Very young plants should not be touched (except to rid them of superfluous buds which tend to form independent leaders) and the second year is the earliest period at which pruning is advisable. A very much more severe pruning is advocated by Mr. McIvor in windy situations, but I have seen such ill effects from this in Ceylon that its adoption is not advisable. The greatest damage done to plants by wind is through the loosening of the stem in the hole, and the subsequent entry of water with fatal effect, the damage done to the upper part of the tree being of little consequence, and it is to prevent this, and for no other reason that pruning should be done.

Disadvantages of lopping.

It is a great mistake to suppose that by pruning the tree grows more rapidly. It is unreasonable to imagine that by depriving the trees of their leaves we can arrive at this result, and observation will shew any one that whilst the pruned tree may perhaps be slightly higher than the unpruned, through its efforts to replace the primaries that have been removed, the girth of stem is far less. It is an invariable rule that the more bushy

the tree, the thicker the stem, and it is this thickness of stem, and not mere height, that contributes largely to increase the yield of bark; whilst as I have shewn before, the alkaloids are first formed in their crude state in the leaves, and thence conveyed to the bark, and therefore it is a mistaken policy to deprive the tree of the source from which the alkaloids are in the first instance derived. In all situations, where exposure does not necessitate it, no pruning of any consequence should be done for three or four years.

Lopping before stripping.

Unless, however, the branches up to a certain point are pruned away, the clean smooth stem, so desirable in all cases where bark is taken in quills, will be wanting, and therefore the tree should be lopped before harvesting the bark, particularly if stripping or scraping is to be the method pursued, a sufficient time being allowed to elapse for the wound to heal over. This lopping has also the effect of checking the tendency to seed, which is injurious to the growth of the tree. Everyone knows the tendency shewn by closely planted trees to shed their lower branches; this in the case of cinchonas would result in the loss of much valuable bark, and a few of the larger primaries should be taken off rather earlier if they begin to interfere with one another, dead branches forming a fruitful source of decay in the parent tree.

Amongst Coffee.

Cinchonas growing amongst the coffee ought of course to be pruned at an early age, to minimise the injury to the coffee caused by shade and drip.

Method of lopping.

In pruning the trees great care should be exercised; the branch should be taken off as close to the stem as possible without injury to the stem bark, by a single upward cut with a sharp pruning-knife. If a notch is left this soon rots, and decay frequently makes its way into the centre of the tree thereby; whereas the stem bark closes over a neat cut in a comparatively short time. In numerous cases I have traced disease to a place where a branch has died, been broken, or badly cut off.

In young trees, double and treble stems should certainly be left on when both or all are equally healthy, for the yield of bark is much greater from two stems than from one, though they may be smaller. A delicate or sickly stem should of course be cut off.

Cost.

The cost of pruning depends so entirely on the circumstances of the clearing that no figure can be named

for it; it is, however, a work that well repays itself from the bark obtained, and the large number of cuttings that may be raised from prunings.

To summarise briefly:—

Summary.

1. In windy situations prune early, leaving two pairs of primaries, and continue a yearly pruning before the wind, leaving the tree thicker at each successive pruning, until its roots have a sufficient hold on the ground to render the work no longer necessary.

2. In sheltered situations, commence pruning before harvesting, or when the trees are so close that the primaries interfere with one another; in the latter case prune as lightly as possible.

3. Cut off all dead branches that are accessible, and if there is a hole going into the stem, plug it with clay.

4. Whittle the bark from all *matured* wood, however small, taking it from large branches in the form of quill.

5. Cut as close to the stem as possible without injury to the stem bark, by a single upward cut with a sharp knife.

6. In young trees do not leave more than three stems; if one of three or two is weak, cut it off close to the junction. In the first year rub off all superfluous buds that tend to form independent leaders, but nothing more than this. This does not apply to young plants with double stems.

7. In large trees, only cut stems when thinning is desirable.

CHAPTER XI.—STAKING.

In windy localities it is always necessary to stake the tree, unless the method of pruning I have advocated is adopted. In some places even this is not sufficient, and staking has to be done in any case.

Effect of wind.

The wind affects the tree in two ways, by tearing the fleshy leaves of large-leafed trees to shreds, and by shaking the young trees so as to cause holes in the ground round the stem, when not only is the bark injured by friction against the sides of the hole, but in wet weather the water enters, and stagnating amongt the roots, rots them. In many cases there can be no doubt that canker at an early age is the result of this action. Prun-

ing to some extent averts both these evils, whilst staking, in itself a dangerous operation, does not prevent the injury to the leaves, but rather increases it, and often causes a breakage of the upper and brittle portion of the stem; it is in fact but the lesser of two evils, and should never be done when not absolutely necessary; sometimes, however, there is no choice in the matter.

McIvor's method

Mr. McIvor recommends the system of driving in two stakes on either side of the tree, and connecting them by a grass rope, which should not touch the stem of the plant, but act as a support to the upper leaves and branches when the tree is bent by the wind. This is an expensive method; a cheaper one is the insertion of a single vertical stake, parallel to and close to the stem of the plant, to which it should be connected by a tie, at a sufficient height from the ground to avoid damage to the top of the tree by breaking; a soft material being put between the stem and the encircling tie.

Vertical stake.

Sloping stake.

Another method requiring greater care, and consequently more likely to result in harm if badly done, is that of driving in the stake at an angle of 45°, the upper end pointing towards the direction of the wind. If carefully done there is no possibility of any movement of the stem in the highest wind, but as this method is only effectual when the wind is constantly in one direction, I think least damage by staking is likely to be caused by the vertical stakes. The cost of Mr. McIvor's method makes it almost prohibitory on a large scale, though it is undoubtedly the best.

The cost of staking by the latter methods is as follows:—

Distance.			*Cost per Acre.*
3½ × 3½	...	...	Rs. 24·50
4 × 4	...	...	18·50
5 × 5	...	...	12·00

It is often necessary to stake young plants, to preserve them from injury. For this, the pegs that have been used when lining are of service, and render the cost of the work much less.

PART IV.

CHAPTER I.

MANURING.

The manuring of cinchona trees is a subject which merits far more attention than it has yet received. The only reliable figures at our command are those obtained by Mr. Broughton, from a series of experiments carefully conducted, but which are not conclusive, though the results are very interesting and valuable.

Ammonic Sulphate and Guano.

A number of *succirubra* trees three years old were manured with 1 ℔. ammonic sulphate, and 1 ℔. guano respectively. These manures, though of a stimulating nature, had no effect whatever on the growth of the tree, and therefore the value of their application depended entirely on the change effected in the composition of the bark.

At the end of 15 months the following statement gives the amounts of alkaloid obtained, calculated in percentages of dry bark, compared with a sample of bark taken from trees of the same age, growing near, under conditions which only differed by the absence of manure :—

	1 lb. Ammonic Sulphate.			*1 lb. Guano.*	
	Man'r'd.	*Unman'd.*		*Man'r'd.*	*Unman'd.*
Total alkaloids	7·25	4·89	...	5·29	4·76
Quinine	2·45	1·78	...	0·91	1·04
Cinchonidine and Cinchonine...	4·80	3·11	...	4·38	3·72

The results of these experiments shew that the increase in alkaloids mainly consists of other alkaloids than quinine, and that it would hardly be profitable to go to the expense of applying even ammonic sulphate, which gave the best results.

The great sensitiveness to the effects of situation, sun-light, and character of soil, shewn by *C. officinalis*,

leads to the supposition that it will be more susceptible to the influence of manure than *succirubra*; but the variations which occur in its bark from apparently slight causes necessitated much care in conducting the experiments. Hence in an apparently homogeneous plot of *C. officinalis*, of the same age as the *succirubra* previously tried, long double rows were selected in which to try the effect of the manure, while the trees between these double rows were left unmanured. To them, 1 ℔. guano, and ¾ ℔. ammonic sulphate were applied respectively. In this case also no apparent change took place in the manured trees, and no extra growth could be observed. After the same period of time had elapsed, careful analyses were made with the following results:—

	¾ lb. Ammonic Sulphate.			*1 lb. Guano.*	
	Man'r'd.	*Unman'd.*		*Man'r'd.*	*Unman'd.*
Total alkaloids	6·51	3·98	...	5·76	4·54
Pure quinine...	4·41	2·40	...	3·11	2·54
Cinchonidine and Cinchonine...	2·10	1·58	...	2·65	2·00

Hence it appears that 1 ℔. of guano increased the total alkaloids in the bark by 2·53 per cent, of which increase 2·01 was quinine; and that the addition of ¾ ℔. ammonic sulphate produced an increase of 1·22 of total alkaloids, and 0·57 of quinine.

Experiments were also made with applications of farm-yard manure extending over four years, the number of applications being 3 and 4. Eighteen months after the last application, bark was taken from the manured trees, and from some similarly situated trees unmanured. The results were as follows:— Farm-yar manure

	Manured.		*Unmanured.*
Total alkaloids	7·49	...	4·68
Pure quinine	7·15	...	2·40
Cinchonidine and Cinchonine	0·34	...	2·28

In this case, as in the previous ones, no change was apparent in the growth or luxuriance of the trees, but the application had the singular effect not only of increasing the alkaloids by 2·81 per cent, but of converting cinchonidine and cinchonine into quinine, making a total increase of pure quinine of no less than 4·75

per cent. Hence the value of the bark was increased enormously, to the extent of eight or nine shillings, above the value of the unmanured.

In all the above experiments, it must be borne in mind that it is extremely improbable that the time of greatest yield after the application was hit upon.

Cost. The addition of 1 ℔. guano to the *officinalis* caused an increase in the value of the bark of some three or four shillings a ℔., the cost of the application amounting in all to about 2½ pence per tree, a very extreme amount. In the case of the farm-yard manure, the cost of each application may be put at eight cents per tree, or 32 cents at the end of four years, the result being a bark increased three or four fold in value. It is probable that a single application, a year or 18 months before the cutting of the bark, would prove most profitable.

Experiments unsatisfactory. All these experiments however are more or less unsatisfactory; for in the case of *C. officinalis*, that very sensibility which makes it most amenable to the influence of cultivation, renders results of this kind of doubtful value, unless we can, by repeating experiments with trees of the same known value, be sure that the results are due to the action of the manure, and not to the chance superiority of certain individual trees. It is noteworthy that *C. succirubra*, which is least susceptible to these variations, and in whose case the results were more dependable, shewed but little improvement from the application. It is, however, highly improbable that in all the experiments with *C. officinalis*, the manured trees were originally of more value than the unmanured; and therefore, though the exact increase of value by manuring is still a matter for experiment, there remains no doubt as to the general benefit received by the tree from applications of nitrogenous manures. This is rendered all the more probable from the fact of the presence of ammonia in Indian cinchona bark, and Mr. Broughton has propounded the hypothesis that this substance, which is itself an alkaloid, is a step in the formation of quinine, &c., and forms the framework of their constitution.

Ceylon experience. No systematic experiments in the way of manuring have as yet been completed in Ceylon, but the general testimony shews that where cinchona is planted amongst the coffee, it evidences by increased luxuriance and rapidity of growth, that it derives benefit from the manures

applied to the latter. Cattle manure is said to have the most beneficial effect, but no doubt because it is the most commonly applied; 1 ℔. coconut poonac, especially if applied with an admixture of ½ ℔. bone-dust, has also been found to yield satisfactory results in point of growth. The effect of manuring on the value of the bark in Ceylon is as yet unknown, but in view of the wonderful results obtained in India, I think we may confidently expect an increase in value which at the least will fairly repay us for money spent. It is a remarkable fact that whereas in India the testimony all points to there being no visible result from manuring, in Ceylon the evidence shews the very contrary, and this should make our hopes of adequate results from high cultivation more probable of fulfilment. Finally, as there is no probability of Government instituting the carefully conducted experiments which would be necessary to set this question at rest; as there is no public analyst to put its settlement within the power of private individuals except at considerable expense; I would urge on all those who have trees of mature age, to try any applications of nitrogenous manures that are in their power; the increased growth of the tree, and the price fetched by the bark in the market, will, if the experiments are sufficiently numerous, be a fair criterion as to the advantageousness or otherwise of manuring cinchona. For many years we manured coffee successfully with no better guides than this, and a few desultory experiments, and this experience will no doubt be repeated in the present case. Apart from the application of manure, an occasional digging of the soil has a markedly beneficial effect on the growth of the trees.

CHAPTER II.—HARVESTING.

There are four methods of harvesting the bark, all of which have high authorities to support them, and which have formed the subject of controversy in India during several years. The four methods are stripping and renewing, scraping, (first practised by Mr. Moens in Java), coppicing, and uprooting. I will first describe the way in which each is done, then discuss generally the advantages and disadvantages of each, and finally point out what are likely to be the best methods to follow in Ceylon.

McIvor's system.

The system of mossing was discovered by the late Mr. McIvor, whose attention was directed to the solution of the problem of how to obtain the greatest amount of alkaloid in the least amount of time. His idea was that by cultivation, both the total yield of alkaloid, and the proportion of quinine in it, could be increased, and in the stripping and mossing process he found the means for attaining this end. The system as described by Mr. McIvor is not exactly what we now pursue, whilst some of his deductions have been shewn to be incorrect, still I think it better to allow him to describe the process as first invented and carried out in his own words:—

"The opinion advanced at first has been already confirmed, namely, that constant and uniform yearly supplies of bark can be obtained by lopping and pruning the trees. This operation being necessary in order to give our cinchona trees straight smooth trunks of from 25 to 35 feet in height from the ground to the first branch, the trunks yielding at the same time large supplies of bark, under the process of pruning and cropping known as the *mossing system*, the *modus operandi* of which I proceed to explain."

"The finest green moss, (or other suitable material), is selected to protect the bark from the influence of light and air, and also to increase the cellular tissue of the bark, as this portion forms the principal receptacle of the quinine. To effect both these purposes, moss has been found a cheap, convenient, and very suitable material, as its presence on the exterior of the bark greatly increases its thickness, and consequently its capacity for the reception of alkaloids. With these observations, I proceed to detail the particulars of the application of moss only, submitting it to be understood that when other material is used variations will be necessary, according to the comparative density or otherwise of the material employed; but ordinary moss should have the preference, as this, as a rule, can be procured in abundance in all localities suited to the growth of cinchonas."

"To be effectual the covering of moss should be from three to three and a half inches thick, laid on uniformly, with the surface or green side of the inner layer (freed from all extraneous matter) next to the bark of the tree, while the outer layer should have the surface exposed to the atmosphere. By covering the bark in this manner, the plant is secured against injury by

fermentation—as this may take place if the inner layer of moss is much mixed with decayed leaves, grass, lichens, &c. When thus put on, the moss immediately begins to grow, especially when used in wet or damp weather; and this is of great importance, because the natural growth of the moss increases its own bulk and thickness around the tree, while the root fibres, and young shoots, ramifying through the moss, effectually secure the whole around the stems and branches to which it is applied. The moss when laid on, is secured by pliable bands of split cane, fibrous bark, creepers, or any other convenient or suitable material, wound round the outer layer in a spiral manner; this being farther secured here and there by cross ties, until the covering of the whole of the bark be completed. The bark, when subjected to this process of protection from light and air for eighteen months or two years, (more or less at the option of the cultivator), is opened out by the moss being divided in a straight line down the stem or branch, and turned back until one-half of the stem or branch is laid bare. The bark now ready for cropping (the process of which will presently be described) has become much improved by the covering of moss. Quinine and other alkaloids are first formed or produced in the leaves by the action of light and air on the juices, and while the leaves are performing their usual office of elaborating the sap or juice of the plant. Here the alkaloids are intimately combined with the elements of the sap, such as quinovic acid, &c., and in this condition carried down by the return sap, and deposited in the bark. Most impure in the liber or inner bark, but as the liber becomes transformed into cellular tissue, a superior alkaloid (quinine) is produced in a state of great purity, and easy of separation. The inferior quality of the alkaloids in the liber is apparently caused by the rapid circulation in this portion of the bark, of sap containing oxygen from recent exposure of the leaves, quinine being most abundant in the cellular tissue of the bark, where it is deposited at first, also in an impure state; but in consequence of the retarded and horizontal circulation of the sap in the bark, the tendency of the alkaloids is to become and pass into quinine. In the cellular tissue, however, there is also a process of waste, caused by the action of light and air on the surface of the bark. Thus the quinine apparently oxydizes, and becomes inseparably combined with or passes into red colouring matter and gum. This process of waste is

however somewhat less than the deposit or accumulation in the bark, and for this reason the alkaloids increase according to the age of the plant."

"From the above it will be understood that if this process of oxydization or waste from the surface is effectually prevented, quinine will be deposited and increased, in the cellular tissue of the bark to a large extent, because the leaves form the quinine laboratory, while the bark is merely the store-house; and doubtless the leaves daily elaborate and deposit a certain proportion of quinine, and will continue to do so till the last day that a healthy leaf exists upon the tree. There is therefore a continued and never-failing alkaloid producing power in action, and the alkaloid thus formed and deposited can be cheaply and most effectually preserved by covering the surface of the growing bark with any material, so as to exclude the action of air. There will of course be a limit to the quantity of alkaloid that the cellular tissue will contain, which probably will be from 18 to 20 per cent of the bulk, and making an allowance for the less pure alkaloids of the liber, from 14 to 17 per cent of pure quinine may be obtained from red bark thus managed. In addition to protecting the alkaloids from waste, it is desirable to increase the cellular tissue, and to effect both these objects moss has been selected to cover the surface of the bark, as this material effectually excludes the light, and at the same time greatly increases the cellular tissue. By this process the yield of quinine can be tripled, quadrupled, or even more, according to the time the bark is subjected to it which to develop its full advantage should be applied for a period of not less than 18 months, a longer time than this being still more advantageous. This process also facilitates the removal and renewal of the bark which constitutes the system of cropping here advocated, and which I now proceed to explain. After the moss has been removed so as to expose the bark in the manner above detailed, a labourer, reaching up as far as he can, makes a horizontal incision of the required width. From either end of this incision he runs a vertical incision to the ground; and then, carefully raising with his kinfe the bark at the horizontal incision, until he can sieze it with his fingers, he strips off the bark to the ground and cuts it off. The strip of bark than presents the appearance of a piece of ribbon more or less long. Supposing the tree to be 28 inches

in circumference, the labourer will take nine of the above ribbons, each 1½ inches wide. He will thus leave after the tree has been stripped other nine ribbons still adhering to the tree, each somewhat broader than the stripped ribbon, and at intervals apart occupied by the spaces to which the stripped ribbons had adhered. As soon as he has removed his strips, the labourer will proceed to moss the trunk all round in the manner previously described; the decorticated intervals will thus be excluded from light and air, and this is one of the capital points in the system. The mere exclusion of light and air from a stem partially bared of bark acts in two ways:—it makes a healthy process to be rapidly set up in the same way as a plaster does a wound in an animal organism, and it has the further curious effect, it increases the secretion of quinine in the bark renewed under its protection. This increase of quinine is admitted by Mr. Broughton in all his reports. At the end of six or twelve months, the bands of bark left untouched at the first stripping are removed and the intervals they occupied on the trunk are mossed. At the end of 22 months on an average, the spaces occupied by the ribbons originally taken are found to be covered with renewed bark, much thicker than the natural bark of the same age, and this renewed bark can be removed, and a fresh process of renewal again be fostered by moss. In another six or twelve months, the renewed bark of the natural ribbons left at the first stripping can be taken, and so on; harvests are obtainable from the trunk alternately from the spaces left at the first stripping, and the spaces left by the second stripping. Experience hitherto does not shew any limit to the taking of these harvests from the tree. Of course it is understood that the ribbons taken at every stripping are larger than at the preceding stripping, because the tree has each year increased in height and bulk, and therefore the top of every ribbon consists of natural bark, and the lower part of renewed bark. All experience hitherto acquired shews that bark invariably renews. It renews easily and early when the cambium is untouched. In cases where the cambium is injured, the renewal proceeds, but the process is slower. In respect of universal renewal there is no difference whatever between the red and crown barks."

Many of the statements and anticipated results in the above have been shewn to be incorrect, particularly the largely increased value attributed to mossed bark; The system as practised generally.

still the system has its merits, and in a modified form is a very valuable one as I shall shew later; for its invention we owe a large debt of gratitude to the late Mr. McIvor. In practice on the Nilgiris, no horizontal cut whatever is made, such as would stop the flow of the juices. The well trained coolies, who are exceedingly careful and skilful in their work, stretch up to their utmost height, and cut down into the very earth without any fear of injuring the tree by the clear downward cut. When four strips hang loose like ribbons (being easily detached from the trunk in wet weather), they are simply jerked off from the top and bottom, and then carried to the drying house. Four equal strips are left on each tree, and men are ready with moss and jungle rope instantly to protect it, the atmosphere having thus no time to set up an injurious action in the cambium. Where a tree is tall, a ladder is required, and five men instead of three to perform the various processes. The lopping of the tree should be done at least six months before the stripping, otherwise the bark will be found difficult to get off, from the check to the flow of sap which attends the former operation.

Coppicing

The process of coppicing is comparatively simple, and consists in sawing down the tree near the ground, leaving a sufficiently high stump for the production of shoots to give further crops of bark. The most suitable tool is a cross-cutting saw, with which the tree should be cut about six inches above the ground. The cut should either be a sloping one from one side to the other, which I have found the simplest, or should have a slope from the centre to either side, by the saw being withdrawn when half through the tree, and a second cut made to meet the first from the opposite side. This precaution is necessary to prevent water from lodging. Where violent winds are prevalent, the advisability of heaping earth round the stocks to above the junction of the stems will be obvious. In the case of trees growing amongst coffee or other permanent culture, the stems will from the time of their springing from the stock be well protected from wind. Amongst groves of cinchona, this method should if possible be employed on all the trees at once, as otherwise the shade of trees left standing checks the growth of the shoots.

Within a month or two after cutting, the stools will in most cases be covered with shoots. This effort of nature to supply the loss of leaves sustained by the tree through coppicing should not be too abruptly

checked. The shoots should all be allowed to grow for some time, until they are several feet high, when all but two or at most three must be removed.

Uprooting.

The process of uprooting explains itself. It is by no means a difficult operation, particularly if the plantation is on a slope, as by taking out the lower rows first those above them are easily taken out of the ground. In conducting this operation, great care should be taken to remove all pieces of root from the soil, as the value of their bark is considerable.

The scraping process I will describe and discuss later; it is the three processes already mentioned which are generally employed, and we will proceed to discuss the general advantages and disadvantages of each.

Advantages and disadvantages of mossing and renewing.

Under the mossing system we are said to get a succession of crops of bark, consisting chiefly of loose cellular tissue rich in alkaloids, and increasing in value every year, without being obliged to resort to methods of obtaining the bark which entail the stoppage of supplies of it from the tree for several years.

We will now discuss the first system in detail. Mr. Broughton's researches have shewn that when the tree has reached the age of maximum yield, mossing and renewing does not increase the amount of alkaloid in the bark, though it undoubtedly does so in younger trees; but it does increase the amount of crystallizable quinine, and thus adds greatly to its value as a source of this alkaloid.

Mossed Succirubra.

The following results of analyses by Mr. Broughton will illustrate this in the case of *mossed succirubra bark.*

	6 years.			*8 years.*	
	Under moss 18 months.	*Natural.*		*Under moss 3 years.*	*Natural.*
Total alkaloids	6·31	5·85	...	7·72	6·36
Quinine ...	1·61	1·60	...	2·02	1·36
Cinchonidine	4·70	4·25	...	5·70	5·00
Quin. Sulph. obtained crystallized	1·19	1·15	...	0·82	0·80
Cinchonidine do.	2·15	2·05	...	3·57	4·02

	8½ years. Under moss 18 months.	*8½ years.* Natural.		*9½ years* Under moss 2½ years.	*9½ years* Natural.
Total alkaloids	6·92	7·61	...	7·80	7·67
Quinine ...	1·09	1·74	...	1·64	1·49
Cinchonidine	5·83	5·87	...	6·16	6·18
Quin. Sulph. obtained crystallized	0·70	0·91	...	0·92	1·01
Cinchonidine do.	4·56	3·18	...	3·65	3·50

These analyses shew that from eight years onward, the application of moss to the bark only increases the amount of alkaloids in a very slight degree if at all; whilst in the case of younger trees, the gain is perceptible but not great; what gain there is, 1·36 per cent in the case of the eight years old trees, consisting of uncrystallizable quinine and cinchonine. It is therefore evident that in this case the gain is not worth the trouble and expense of applying the moss and keeping it on.

Renewed Succirubra.

In the case of *mossed and renewed* bark the case is different, as the following analyses will shew :—

	5¼ years. Natural.	*5¼ years.* Mossed and Renewed 18 months.
Total alkaloids ...	5·66	9·27
Quinine	2·15	3·43
Cinchonidine & Cinchonine	3·51	5·84
Sulphate quinine cryst.		2·58
,, cinchonidine cryst.		4·88

	8½ years. Natural.	*8½ years.* Moss Renewed 18 months.
Total alkaloids ...	6·36	6·39
Quinine	1·36	3·21
Cinchonidine & Cinchonine	5·00	3·18
Sulph. quinine crystallized	0·90	2·30
,, cinchonidine cryst.	4·02	3·03

	10 years.	
	Natural.	*Moss Renewed. 3 years.*
Total alkaloids ...	6·12	6·12
Quinine	1·50	3·37
Cinchonidine & Cinchonine	4·62	2·75
Sulph. quinine crystallized	0·85	2·27
,, cinchonidine cryst.	3·41	2·91

These analyses shew that the renewed bark is of very superior quality to the natural bark, the amount of quinine being greatly increased, though much of it is uncrystallizable. The amount that crystallizes does so with a readiness similar to the quinine from the Crown bark, and with far greater ease than in the case of natural red bark. The alkaloids of renewed red barks, however, are contaminated with a greater amount of red colouring matter than the natural; but this affects their value in a less degree than the comparative ease of the crystallization of the sulphates.

The last set of figures shew that as much as three years mossing does not improve the bark.

At the end of 20 months, the renewed bark is found to be rather less than half the thickness of the original bark in the old trees, whilst in the case of the young trees it is almost two-thirds in the 18 months.

To obtain satisfactory figures for *C. officinalis*, great care had to be used by Mr. Broughton from the variability in amount of alkaloids induced by various climatic conditions. The first analyses are for mossed barks. Mossed Officinalis.

	5½ years.		
	Mossed.	*Natural.*	*Difference.*
Total alkaloids ...	4·73	3·10	1·63
Quinine	2·96	1·62	1·34
Cinchonidine & Cinchonine	1·77	1.48	0·29
Sulph. quinine crystallized	2·55	1·64	0·91
,, cinchonidine cryst.	0·94	1·14	0·20

	6½ years. Mossed.	Natural.	Difference.
Total alkaloids ...	7·41	5·26	2·15
Quinine	4·57	3·48	1·09
Cinchonidine & Cinchonine	2·84	1·78	1·06
Sulph. quinine crystallized	4·46	5·25	1·21
" cinchonidine cryst.	1·74	2·04	0·70

These results shew very favourably when compared with those previously given for *C. succirubra*; in the elder lot of trees, the amount of total alkaloids was increased by 2·15 per cent, of which 1·09 was quinine, yielding nearly its due amount of sulphate; in the younger lot the gain is 1·63 per cent, of which 1·34 per cent is quinine, 0·91 per cent of it being crystallized. Neither in the case of *C. officinalis* nor *C. succirubra* does mossing increase the bulk of the bark in any way whilst the amount of water in it is slightly more.

Renewed Officinalis.

The figures for renewed crown bark are as follows:—

	8 years. Renewed 2 years old.	Natural.	Difference.
Total alkaloids ...	5·83	3·61	2·22
Quinine	3·34	2·34	1·00
Cinchonidine & Cinchonine	2·49	1·27	1·22
Quinine sulph. crystallized	3·13	2·10	1·03
,, cinchonidine cryst.	2·60	1·44	1·16

	9 years. Renewed 2 years old.	Natural.	Difference.
Total alkaloids ...	7·03	6·04	0·99
Quinine	5·21	4·77	0·44
Cinchonidine & Cinchonine	1·82	1·27	0·55
Quinine sulph. crystallized	4·57	4·80	0·23
,, cinchonidine cryst.	0·58	0·92	0·34

The renewed bark had been allowed to attain the age of two years, as it was found to be too thin to be taken after 18 months. In this case, as with the red bark, the yield of alkaloids in the renewed bark exceeds that of the natural bark, to the greatest extent on the younger trees. This is a discouraging indication that as the tree gets

older, the increased value of the renewed over the natural bark becomes less. But the renewed bark forms quicker on the old trees than on the young, thus offering a contrast to *C. succirubra* in this respect.

Crystallization of Alkaloids.

Unless for the manufacture of *amorphous alkaloids*, the value of cinchona bark depends on the quantity of crystallizable sulphate it contains, not on the total amount of alkaloids. At the end of twelve months under moss the total amount of the alkaloids is as great as six months later, but it is during this interval that the change takes place which renders the greatest amount of them crystallizable.

Mr. Howard has found also that the yield of alkaloids increases with each renewal, but as this was only tried up to the age of extreme value of the bark, it does not follow that such increase of value would continue with the tree in its decadence.

Latest results from India.

The latest results from the Nilgiris shew that mossing and renewing in the case of *calisayas* is a failure, probably from the spindly habit of the tree, and its inability to stand the shock of the process. With *angustifolia*, the amount of crystallized quinine sulphate was increased from 2·78 to 6·54, a wonderful result. In the case of ordinary crown bark from Dodabeta, that is, bark of C. *officinalis* with ordinary sized and big leaves, mossing seems to have largely increased the proportion of quinine, the natural barks giving crystallized quinine sulphate 1·92, the mossed 4·78. In the case of C. *pubescens*, whilst the mossing appeared to lessen the amount of quinine and cinchonidine, renewing largely increased the former.

In one of the latest sales, that of May 4th, 1880, natural *pubescens* bark fetched 5s. 1d, and mossed 5s. 4d., a result whieh speaks unfavourably for this process alone. On the other hand in one instance with C. *condaminea*, the result was an increase from natural to mossed, and renewed; crystalline quinine sulphate in the first case being 1·62, in the second 3·00, in the third 4·58.

Java.

In Java, Mr. Moens has tried the mossing and renewing processes largely, and published the results in the form of numerous analyses. *Mossed succirubra* shewed a slight increase in value, but only such as might be accounted for by the increase in age of a year, the period during which the moss was applied. *Renewed succirubra* gave the wonderful result of 11·20 per cent total

alkaloids, of which 3·52 was quinine. In the case of *ledgerianas* there is some confusion, analyses Nos. 33 and 34 give original bark 7·49 per cent quinine, renewed 3·68 per cent quinine, and original bark 8·68 per cent quinine, renewed 5·40 per cent quinine respectively, a result very much against the system. On the other hand, Mr. Moens constantly speaks of the process as applied to *ledgerianas* being a great success, one of the analyses shewing 6·86 per cent quinine in renewed bark eleven months old. It seems probable that the renewed bark in the former case was insufficiently matured. *Renewed officinalis* bark is also very satisfactory, 6·05 per cent quinine being obtained in one instance after two years growth.

Recent Sales. I will now give the results of a few recent sales, which shew precisely what the comparative values of natural, mossed, and renewed barks are at present.

Government grown bark sold May 14th, 1880.

Crown.	*Red.*
Renewed, 8*s.* 4*d.* to 10*s.* 2*d.*	Renewed, 5*s.* to 6*s.* 4*d.*
Mossed, 6*s.* 4*d.* to 7*s.* 10*d.*	Mossed, 4*s.* to 4*s.* 6*d.*
Natural, 4*s.* 8*d.* to 6*s.* 1*d.*	Natural, 2*s.* 10*d.* to 4*s.* 1*d*
Branch, 2*s.* 7*d.*	Branch, 1*s.* 2*d.* to 3*s.* 1*d.*
	Root, 2*s.* to 3*s.* 1*d.*

If it be remembered that the mossed red bark here referred to is no doubt similar in character to the finest natural, which fetched 4/1, the increased price becomes very small. In the case of the crown barks, as before, the difference is marked.

Again :—

Crystallized Sulphate.			*Alkaloid.*		*Price.*	
Quinine,	*Quinidine,*	*Cinchonidine.*			*s.*	*d.*
3·78	.12	2·07	3·12	Red renewed	6	0
2·00	·00	3·46	1·50	,, natural	3	3
2·04	·00	3·54	1·64	,, ,,	3	8
3·70	·00	2·34	3·10	,, renewed	6	0
5·54	·00	1·14	·42	Crown ,,	9	3
3·20	·00	1·13	·14	,, natural	6	1
5·22	·11	1·14	·28	,, renewed	10	3
3·16	·00	·66	·29	,, natural	5	6
4·70	·17	·78	·30	,, renewed	9	9
5·28	·25	1·13	·13	,, ,,	10	0
3·05	·00	1·34	·25	,, ,,	6	6
2·69	·08	1·65	·35	,, natural	5	9
2·65	·03	1 08	·20	,, ,,	5	3

Crystallized Sulphate.			*Alkaloid.*			*Price.*	
Quinine,	*Quinidine,*	*Cinchonidine.*				*s.*	*d.*
5·27	·28	·77	·15	,,	renewed	9	7
3·87	·14	2·82	2·30	Red	,,	6	2
3·46	·10	2·47	2·90	,,	,,	6	2
3·62	·07	2·34	2·60	,,	,,	6	2
1·44	·00	4·35	1·80	,,	natural	3	6
1·56	·00	3·74	2·12	,,	,,	3	11
1·32	·00	3·99	1·97	,,	,,	2	3

Value of Alkaloid percentages.

According to Messrs. Rucker and Bencraft, in the present market, one per cent of quinine is worth 1*s.* 9*d.* to 1*s.* 9½*d.* There is very little variation from this valuation, the bark being apparently nearly always sold on that basis; and, by inference, on a quinine basis only. The truth is that there is rarely less than two per cent of quinine without increased richness of other alkaloids, the presence of which will bring up the price obtained to the standard named. But it is not really until three per cent bark is reached that it is bought exclusively on the quinine basis.

Objections to the system.

With regard to the certainty with which bark renews itself, this is merely dependant on careful or careless work; for if the cambium is not injured, and the moss applied at once, it is sure to form. Another objection, at one time strongly insisted on, has been blown to the winds by experience; it is not true that the renewed bark abstracts alkaloids from the original bark. On the contrary, strips of original bark left on in juxtaposition with renewed bark, have gained in alkaloids in proportion to the longer time they are left on the tree, while the renewed bark has been exceptionally rich, as I have shewn before. One of the real objections to the method is the shock to the tree, which does not appear to grow much whilst subjected to the process, whilst sooner or later it will die from the shock of repeated barkings. It is also a work that requires constant European supervision, for bark only successfully renews when it forms over the whole surface simultaneously, and any damage to the delicate cambium surface causes a wound which can only be covered by lateral growth from the cut edge of the natural bark, and which if not so covered by decaying introduces disease to the stem. It therefore happens that in practice a certain proportion of the strips fail entirely to renew their bark, and others only do so partially. The operation of barking is much more difficult with *officinalis* than with *succirubra*; but the renewal, though slower, is found to be more certain with the former than with the latter, whilst as

has been shewn before the increased value is far greater. The only time of year when it can be successfully performed is the wet season, and this is the very time when it is most difficult to dry the bark for exportation, and when it is least rich in alkaloids. The system has proved a complete failure in Sikkim, from the attacks of ants, the renewing bark being regularly eaten by them, and the moss itself being used as a habitation.

Renewal without covering.

In India, barked trees have renewed fairly well without any covering; and in Ceylon, with trees close together and shading one another, the method is attended with a certain amount of success, particularly in wet climates; but a very small amount of direct sunshine on the cambium gives rise to the appearance of the well known and fatal red colour, when all hope of renewal must be abandoned, and the probability of the decay and death of the tree be faced. Mr. David Howard writes as follows: —

"With regard to the renewed bark my experience, as far as the few samples of bark renewed without covering go, seems to shew that what is renewed in the dark under moss or other covering contains a higher proportion of quinine than what has been renewed in the light without covering. I have not enough experience to shew, to speak with certainty, still less can I say if the difference is owing to the light or to the freer growth of the bark, under moss."

In some cases, bark renewed without covering has been found to become corky, and apparently of little value, but whether such bark is as a whole inferior or not is as yet uncertain. Mr. Moens appears to think that the superiority of renewed bark is in no wise due to the covering employed, but to the process of renewal only. On the subject of mossing "pure and simple" Mr. Howard writes: "I have absolutely no certain information, as all the mossed bark we see is from trees on which renewing is practised, and therefore it is a question whether the *mossing* or the changes in the health of the tree caused by the removal of the bark, has caused any improvement that is shewn. We must also remember that the mossed bark is always older and therefore more matured than natural bark from the same plantation. When mossed and natural bark are sent from the same plantation, I have found that in Crown bark the mossed bark is both richer in total alkaloids and in the proportion of quinine than the natural bark, but I am quite unable to say how far this is due to the moss, how far to the shock to the tree of renewing, and how far to increased age."

"Samples of Crown bark from Ceylon which have attained a full maturity without moss, test almost if not quite as well as mossed bark from Madras. I am inclined, however, to think that there is less cinchonidine in proportion to the quinine in the case of mossed than of unmossed bark, and so far to agree with Broughton's opinion that light caused a development of cinchonidine."

"In the case of red bark, I cannot certainly trace any change in the mossed bark that may not be traced merely to age; being older, the total alkaloid is almost always greater, but the proportion of quinine is by no means always larger. In some cases it is so, in others markedly the reverse, and I have found some samples of unmossed bark, richer in quinine than any mossed samples that I have examined." Judging from experience it seems unadvisable to attempt to strip and renew without covering, except on a small scale experimentally. The expense of covering, now that we find that *growing* moss is not necessary, and that other materials, as I shall shew later, are eminently suitable, is comparatively small; and to avoid it whilst risking the health of the tree, to say nothing of the jeopardy of the anticipated renewed bark, is false economy. It is quite possible that experience may teach us that in certain localities, and at certain seasons, covering the renewing bark may be dispensed with; but the experiment should only be conducted with a full knowledge of the probable consequences of failure.

Effect of continued stripping.

On the Nilgiris, some of the Crown bark trees have been barked and mossed four times, and the red six times. They both bear the operation wonderfully well, but their appearance seems to shew that their vigour has been greatly reduced thereby, which is made more marked by the greater tendency they shew to blossom and seed than their unbarked neighbours. It now takes them three years to renew their bark, and even then it is very thin. Mr. Broughton says that for months after taking the bark, the growth of the tree ceases; it appears unhealthy, the colour of the leaves changes to yellow or red, and it has generally a more or less sickly aspect. But after a time it recovers its health, and at the end of a year reassumes its healthy appearance and growth. Mr. Rowson instances trees, 17 years old, which are being stripped for the seventh time, and giving an average of four and one-tenth lb. dry bark.

In all probability the best plan will be found to be a combination of the stripping with the coppicing system,

which I am about to discuss; and I will shew presently what will probably be found most suitable in Ceylon.

Appearance of bark.

In unmossed bark the brokers used to shew a preference for that which is covered with lichens, giving it a "bright silvery" appearance, as an indication of the maturity of the tree from which it is taken; this idea is now obsolete, and "druggists quill" apart, bark is bought solely on its analysis. In mossed and renewed bark these lichens are of course absent.

Disadvantages of coppicing.

The disadvantages in coppicing are that the stools may fail to send up shoots,—in which case the root should be taken up and barked before it is too late, and its place supplied by a plant—; and that the shoots from partial coppicing are in many cases a failure, a large number of the stools failing to produce shoots, whilst those that do grow are thin and sickly. It must also be remembered that whereas in mossing a crop of bark is obtained at an early age, trees to be coppiced with the greatest advantage should be left until they arrive at maturity.

Comparison of renewing and coppicing.

It has been strongly insisted on by Mr. McIvor, that more bark can be taken from certain trees in a given time by the mossing than by the coppicing process, and that the value of it is far greater. The following illustration is given:—1000 Succirubra trees, eight years old, were mossed, in the four succeeding years they gave the following crops.

2,980	lbs. in	1871-72	dry.
764	,,	1872-73	do.
1,546	,,	1873-74	do.
770	,,	1874-75	do.
6,060			

On the other hand, 240 trees were coppiced, 200 of them being eight years old, and 40 of them 5½ years old. The whole quantity obtained was 355 lbs. or 1·48 lb. per tree. The mossed trees therefore yielded 6 lb. of dry bark per tree, against 1½ in the case of the coppiced trees; the former being in part valuable mossed and renewed, the latter mixed trunk and branch bark. These figures would be conclusive but for two qualifications which are striking, and which completely spoil them for any purposes of comparison. The 1,000 mossed trees gave 3 lb. bark each in 1871-72 from their stems, whilst the 240 coppiced gave 1½ lb. only from stems and branches, so that the former must have been so much larger and more vigorous as to make the comparison an unfair one. Again, in 1875, the shoots of the coppiced trees would have been four years old, and

capable of yielding a valuable crop, but this is not taken into account at all. We have no reliable information as to the total yield by each method from which a comparison can be drawn.

There appears to be little doubt that up to a certain period, a partial stripping of bark from a tree does not very materially injure its growth; this being granted, it is evident that as long as the bark renews itself rapidly, there must be an actual gain in the amount of bark harvested; in addition to which comes the very largely enhanced value possessed by such bark. The advantages on the side of *successful* renewing over coppicing are I think conclusive.

Coppicing in Sikkim.

In the Sikkim plantations, the following results were arrived at for coppiced trees. The average height of coppice shoots was 12·4 feet in five years, and from 2·20 to 3·91 feet in one year; the percentage of stools which failed to shoot varying from two per cent in the case of a clean coppice free from shade, to 36 per cent in the case of coppiced trees densely shaded by those left standing. In the former case the average height in one year was 2·88 feet, in the latter 3·27 feet, but the shoots were very spindly. These results are decidedly satisfactory in point of growth, but shew that the more trees are coppiced at one time, and consequently the less shade afforded to those coming on, the more favourable the results; the attendant disadvantage being increased cost of weeding. Recent analyses by Mr. Wood have shewn that in Sikkim the yield of alkaloid is much the same in coppice shoots from three to four years old, and in healthy trees from four to eight years old.

On the Nilgiris.

On the Nilgiris, shoots from stumps of *C. Succirubra* have attained a height of from 12 to 15 feet in three years after coppicing; an analysis of a mean specimen of their bark giving total alkaloids 6·34, of which quinine was 1·37, and cinchonidine and cinchonine 4·97. Considering that the shoots were so young, this is a most satisfactory result.

In Ceylon.

In Dolasbage, Ceylon, three-years-old shoots of *C. Succirubra* are reported as 20 feet high, and 18 inches in circumference, none of the stools having failed to send out shoots. In the case of the cinchona (*Succirubra*) grove on the Nan-oya estate Dimbula, very good results were obtained from the first shoots that sprung from the coppiced stools, but the process could not be carried to a second coppicing, and the stools had to be uprooted. In Ouvah, on the other hand, three successive crops have I believe been harvested, with a very large increase in the amount of bark obtained each time, the original stools being still perfectly healthy.

In all the districts of Ceylon, coppicing is reported as a great success, provided the trees are healthy and young. Trees under shade send out shoots freely, which grow well at first, but unsatisfactorily afterwards, and it is this which is the chief objection to thinning plantations by merely coppicing the trees, and on this point Mr. Moens advises the total coppicing of *Succirubra*, but considers that alternate rows only of *Officinalis* and *Calisaya* need be taken if the trees are not too close. Where cinchonas amongst the coffee are coppiced, there are the most important elements of success present, shade to the stools, and to the young shoots at first only. If at the time of cutting there are suckers growing from the lower part of the stem, success is more certain.

Coppicing and uprooting compared.

In comparing the advantages of coppicing and uprooting the following figures from the Sikkim plantations are interesting. Eight acres of red bark trees uprooted yielded 16,910 lbs. of bark or a little over 2,000 lbs. per acre, in the following proportions :—

Root	6,174 lb.	or 36	per cent.
Stem	6,881	,, 41	,,
Branch	3,855	,, 23	,,

Again 12½ acres, still of red bark trees, were uprooted, and the results were :—

Root	13,763 lb.	or 42	per cent.
Stem	9,965	,, 30½	,,
Branch	9,000	,, 27½	,,

The root bark thus obtained is by far the most valuable portion of the crop, and constitutes 36 per cent in the one case, and 42 per cent in the other. I have obtained the following results myself from uprooted trees of red bark :—

Root	430 lb.	or 24	per cent.
Branch	301	,, 16½	,,
Stem	1,084	,, 59½	,,

and from Crown bark :—

Root	542 lb.	or 43½	per cent.
Branch	103	,, 8½	,,
Stem	595	,, 48	,,

We also find that the more robust the trees, the smaller becomes the proportion of root to stem and branch bark. In the case of the Crown bark, all the trees being of the small leafed variety, the value of the root bark certainly constitutes a half of the results in the instance in question.

Were it the case that seedlings in all cases come on as quickly as shoots from coppiced trees, the case in favour of uprooting would be conclusive. But this is not so ; coppice shoots, in the case of the robuster species especially, growing

with a rapidity considerably greater than that of plants. I think it will be found, therefore, that in the case of *Succirubra* and the robust varieties of *Officinalis*, coppicing, for one crop at any rate, will prove the most remunerative method ; whilst for ordinary kinds of *Officinalis*, where the root bark forms so valuable and large a proportion of the crop, uprooting would appear to be the more paying system of the two. There is, however, one important qualification to this. Can land in Ceylon be replanted with cinchona after a crop has been taken from it ? As far as our experience goes the answer appears to be—no. The self sown seedlings found growing when the old trees are removed grow fairly well, but not nearly as well as there predecessors, whilst fresh plants seem to fail utterly. The effect of manure, or of a year or two of fallow, has still to be tried.

Mr. Moens system of Scraping.

There is another method of harvesting the bark, which is now beginning to attract attention, and which is very well worth a trial. I allude to the system of shaving off the outer layers of bark, leaving the inner layer or liber, immediately overlying the cambium, intact. Theoretically this should be a very good method, for it is certainly an immense advantage not to expose the cambium to injury, whilst the outer layer of bark is the richest in alkaloids, especially quinine ; the inner layers containing chiefly cinchonine. This method is most suitable for the barks which do not rely on their appearance for value, *Officinalis*, and *Calisaya*. In the Java *ledgeriana* bark, there is an average of 6 to 7 per cent of quinine, whilst in the bark thus peeled there is 8 per cent of quinine, and absolutely no cinchonine, which occurs to the extent of ·5 per cent in the bark as a whole. In *C. Succirubra*, the liber or under portion has been found to contain 5·94 per cent of alkaloids, 0·7 only being quinine ; whilst the outer or cellular portion yielded 7·98 per cent of the former, containing 2·25 per cent of quinine. A similar, though slightly different result, has been quoted in a previous chapter.

In Java, trees which have been "scraped" in this way have renewed their bark much more quickly, and shewn less signs of injury, than those stripped on McIvor's system. Renewed ledgeriana bark is reported as attaining, in three months after scraping, three quarter the thickness of the original bark, and to renew as rapidly without covering as with, though it is possible that analysis might shew it to be inferior in value. Messrs. Moens and Sheffer have decided that when only a little of the original bark remains over the cambium layer, the renewal originates wholly in the

cambium, and that the inner layer of old bark, which remained after the scraping, is thrown off like leathery cork. If the scraping is less thorough, so that a thicker layer of original bark is spared, then this is not thrown off, as cork, but the formation proceeds from the medullary rays to the outer edge of the bark fibre layer. This system is the invention of Mr. Moens, who still speaks as favourably as ever of it, and with reason, for it has several undoubted points of superiority over any other system yet employed. In the first place, the quality of the bark taken is much higher than if the whole thickness is removed; again, the risk that attends other barking operations is absent, as long as the process is carefully conducted, for the cambium layer need never be exposed at all; and finally, the renewal appears to take place with equal certainty whether the denuded stem be covered or not. This bears out what has been said with regard to renewal of the bark without covering in Ceylon when stripped in the usual way, namely, that as long as it is not exposed to any direct sunlight the renewal is sure, provided the cambium has not been injured by the process; but that a very short exposure to the sun puts a stop to all chance of renewal, by the drying up of the exposed juices. It must also be remembered that the "scraping" process is performed over the whole stem, and not over a half only as in McIvor's system, so that the diminished thickness is more than made up for, whilst the operation can be repeated every alternate year. A correspondent of the *Ceylon Observer* who has just visited Java, instances the case of a tree from which thirteen-thirtieths of an inch of bark were scraped off. Two years afterwards ten-thirtieths of an inch had been renewed. This was a ledger tree, but officinalis recovers much more rapidly. The same correspondent tells us to scrape as lightly as possible with an ordinary pruning knife, so that the shavings shall be very thin, and stop when the character of the bark begins to change. The chips so taken may be quite small. The value of the natural bark taken under this system is, as has been shewn, greater than that of the whole bark of the tree, from the large proportion of cellular tissue of which it consists. The following is what Mr. Howard writes on the subject:—

"What limited information I have since been able to gather, makes me think favourably of the new (*i. e.* Mr. Moens') plan. I have received from Madras four little samples of bark, viz: 1st natural bark shaved off; 2nd, the bark which had formed under moss after shaving last year; 3rd, bark which had formed after shaving in the air; and 4th,

the bark renewed by McIvor's plan—all from the same tree. No. I. was far superior to the entire bark from strip IV. which I tested last year, which gives the advantage of shaving in the first crop. Nos. II. and IV. were almost identical in test, and shewed the full effect of renewing. No. III. was equally rich in total alkaloid, but not quite so rich in quinine as the other two—viz., Nos. II. and IV.—but still greatly improved by the process. If this is found to be generally the rule, it will simply be a question for experience —'does the somewhat increased proportion of quinine produced by dark *and* damp, or damp *or* dark, pay for the covering?'" I have tried this method myself to a small extent, covering the wounds with moss, &c., and I have found the bark renew most satisfactorily all over, except where the knife has gone too deep and touched the cambium. It is evidently an operation that would require much care and skill to be successful, but the very great advantages it appears to possess, make it a method which should have full trial. This part of the subject would be incomplete without mention of a new system of renewal, the credit of which is due to Mr. A. T. Karslake. The strips of bark are separated from the stem as in MacIvor's system, except that they are all left adhering to the tree by the upper end. The invention consists in their being at once replaced and firmly bound. After a lapse of time which is as yet undetermined, the bark is removed entirely, and the growth of renewed bark, which should have been well developed, is left to itself. This plan is still a matter for experiment, but there is no doubt that on healthy trees the bark renews freely, and the extreme simplicity and cheapness of it should render it of great value.

With regard to the ages at which trees arrive at maturity, the following are a series of analyses by Mr. Broughton, of *C. Succirubra* at different ages:— Maturity of trees in India

	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.
Total Alkaloids.....	6·74	7·43	7·60	7·85	7·67	7·38
Quinine.................	2·40	1·72	1·73	1·80	1·49	1·31
Cinchonidine and Cinchonine..	4·34	5·71	5·87	6·05	6·18	6·07
Sulph. Quin. Crys....	2·21	1·51	1·40	1·15	1·10	0·83
Do. Cinchonidine do.	2·85	4·92	4·60	4·30	3·86	3·01

These analyses shew an increase of total yield of alkaloids up to the 9th year, and then a decrease; the amount of quinine and cinchonidine decreasing concurrently with

an increase of cinchonine. Mr. Broughton's conclusion was that the trees in question had passed the age of maximum yield, and he accounted for it by the growth of the bark at this age being mainly an increased development of liber fibres, and not of cellular tissue. He also considers it as probable that a waste of the alkaloids commences from the first year, but is counterbalanced by the rapid simultaneous formation of alkaloid in the earlier years up to the 9th, when the formation becomes less active, and deterioration is the result.

In the case of *C. officinalis*, from the great variability in the quality of its bark, the changes cannot be determined with accuracy; a deterioration has, however, been established from the ninth to the tenth year, it is said. This result is, however, very doubtful, and I do not think any stress can be laid upon it.

In Ceylon.

It is certain that in Ceylon our trees arrive at maturity sooner than in India; that is, they yield a good marketable bark earlier. At what period the bark attains its extreme value there is absolutely no evidence of any kind to shew, but trees of considerable age have, I believe, yielded valuable bark. This early maturity is coupled unfortunately with early decay, which probably prevents the trees in most cases attaining the period of extreme value, and therefore our ignorance on the subject is of less consequence. It is not difficult to assign a reason for this early decay, which affects sooner or later the greater portion of most of our plantations. The fault lies in our soil, which as a rule is of no great depth; and in our sub-soil, which is for the most part of a somewhat impervious character. When we read of the Java plantations having a rich surface soil twelve to fourteen feet in depth, and remember the very great superiority of the soil of the Indian plantations over our own, we need not feel surprised at the great comparative longevity enjoyed by their cinchonas. There are no doubt some localities, probably more numerous in Uva than elsewhere, in which cinchona will reach a considerable age; but as a general rule the life of plantations is short, and we ought to be very thankful that we have a climate which induces such rapid growth, and early maturity, as to enable us to hold our own with countries in some respects so superior to our own. With Java I fear we, in common with all India, must confess inferiority in all respects. A succirubra tree fourteen years old, 63 feet high, and 3½ feet in girth; a calisaya tree seventeen years

old, 60 feet in height, and 3 feet in girth; and a ledgeriana thirteen years old, 48 feet high, and 3 feet in girth, are far beyond any thing we have to shew. The Kalugalla estate succirubras, 45 feet high, and 49 inches in girth at the base, are good growths for fifteen years, but nothing to the preceding. With India, in spite of our inferiority of soil, we have the decided advantage up to a certain point, quite sufficient for practical purposes.

Isolated trees apart, six or seven years in the case of *succirubra*, and five or six years in the case of *officinalis*, appear at present to be the limit of healthy growth of *plantations* in ordinarily good soil. These limits are contracted or extended by any particular stiffness or goodness of the soil, and we may find that in some localities, probably in Uva, these limits can be considerably extended. Longevity of plantations.

A remarkable instance of the early maturity I have insisted on is given by Mr. Northmore. The bark is from succirubra trees in Pussellawa, twenty-one months old, grown at an elevation of 4,000 feet. Mr. C. E. H. Symons, by whom it was analysed, writes thus:—The bark "contains total alkaloids 3·870 per cent, of which crystallized sulphate of quinine = 1·533 per cent, which would give a gross value in the London market of 2s. 6d. per ℔. I may state that the proportions of cinchonidine and quinidine are very good, the percentage of cinchonine being small." The trees were grown in old coffee, and had probably to some extent benefitted by applications of manure. Three and a half years old red bark has fetched from 2s. to 4s. per ℔., and crown bark of the same age from 5s. to 6s. The latter was also designated by Messrs. Howard as "good marketable bark as it stands, but we advise you to give the trees a couple more years." From the little that has been as yet tried of it, calisaya bark appears to become matured at as early an age as officinalis. Instance of early maturity.

The amount of water in the bark which is dispersed in drying varies considerably with the weather, and season of the year; the loss being greater in wet than in dry weather. On the Indian plantations the loss is roughly as follows, the percentage representing the weight of dry to wet bark:—*C. officinalis*, 36 per cent; *C. calisaya*, 33 per cent; *C. succirubra*, 30 per cent. This loss decreases with the age of the trees. It also varies greatly according to the elevation or climate in which the bark is grown, and the character of the bark Loss by drying.

itself. The bark of *C. officinalis* at high altitudes is reduced by drying to 40, and in some cases only to 50 per cent; natural bark of *C. succirubra* to 25 per cent at low altitudes; and to as much as 36 per cent at high altitudes; whilst renewed bark has given 39 per cent dry. Ordinary bark as exported contains from 10 to 12 per cent of water.

Best system for Ceylon.

And now with regard to the most profitable system to be followed in Ceylon. We have very insufficient data to shew what is the increase in the amount of bark yielded per tree from year to year, still it is evident that the ratio of increase becomes larger the longer the trees are allowed to grow; on the other hand, we have to consider their short period of growth, and early maturity. This is a subject on which Government should have taken some action, as it is a matter beyond the capabilities of private individuals. All we can do is to collect and compare the experiences of those who have tried the various systems. Mr. Taylor of Lool Condura, whose experience entitles his opinion to great respect, has decided in favour of up-rooting; many others on the contrary have had cause to put faith in the mossing and renewing processes. That bark will renew itself, and rapidly too, in Ceylon, there can be no doubt; some officinalis bark having been known to attain the full thickness of the original bark in less than a year. Whilst in every district the operation appears to be attended with fair success, particularly when the trees are young, and the operation is performed in wet weather. For the covering material, where moss is not attainable, many substitutes may be employed. Maana grass especially, or old bags, I have found effectual; but the danger with the latter is the attack of insects. A layer of earth enclosed by sacking has been suggested, as also a covering of cowdung and clay, which I believe has proved a success. Judging from experience, all that is necessary is the exclusion of too much light and air, and protection from the direct rays of the sun, particularly at first; retention of moisture not being necessary. For this purpose, moss is the best material; but where its application is expensive, grass is a cheap and effectual substitute. As I have said before, I would not advise attempts at renewing on a large scale without any covering, until the method has been thoroughly tried. I do not believe that the extra risk of the method is in proportion to the trifling expense of covering with grass. As to the ill effect of these operations

on our trees, there can be no doubt that in many cases it is injurious, particularly where a defective renewal of bark leaves exposed the sap-wood for the entrance of decay. As a general rule however, the ill effect is only temporary, and should not affect our employing the method, where we find it answers to do so. The method of harvesting, which I should suggest as being the best to follow in Ceylon, will commence by fairly close planting, such as I have previously advised, and a rooting out of a proportion of the trees when they commence to crowd each other. From time to time, a certain number will shew signs of decay; where the trees are growing thickly, these should be rooted out. Where the trees are not too thick, they should be up-rooted only if the disease arises from the roots, the vacancy being supplied; and coppiced, if it is merely a local disease on the stem. In the case of small varieties, I would recommend up-rooting in any case. A system of stripping and renewing should be commenced when the trees are sufficiently robust to stand the operation. It is impossible to state the period at which this may be begun; it varies in the several districts, and for the different species and varieties, but will be found to lie between the third and fifth years of growth. In this connection, I may repeat the advice insisted on by all authorities against a premature commencement of the harvesting process. Financial reasons frequently lead to this, but it must always be borne in mind that the increase in value of the bark from year to year is out of all proportion to what is gained by an early harvest. Six months before this period, the stem should be freed of all lateral branches which would interfere with the stripping. As soon as the trees so treated begin to shew signs of decay or exhaustion, they should be coppiced or up-rooted. In the case of robust species, a clear coppice of the whole plantation is best, the small varieties only being up-rooted.

Method of Stripping.

In taking the first year's crop, half the stem bark of the tree should be removed, and when the denuded stem is well covered with the renewed bark, the portion left after the previous operation may be removed. The smaller the strips taken, the more probable the renewal, as the cambium is less exposed, whilst there is less fear of injury from the barking knife. There is however the consideration of cost, which is greater than if a few larger strips are taken, whilst it may cause a greater shock to the tree. In India, three strips of as nearly as possible equal width are left on and taken off. It is the opinion of many, however, that three strips are too few, and that a greater number of

narrow strips are better: that, a tree being 20 inches in circumference, five strips, each two inches broad, should be taken. I have mentioned the stripping process as being the one to employ, because it is the more generally known and practised, but I believe that extended experience will cause us to substitute Mr. Moen's scraping process for it if Mr. Karslake's improvement is found impracticable. This substitution would, however, in no way affect the mode of procedure here advocated. The number of operations which the tree will stand, and the period which will have to elapse between each, can never be exactly fixed, as they will depend on the robustness of the individual tree, as well as on exterior influences. It will probably be found that an annual crop can be taken from young healthy trees, the period lengthening as the tree grows older.

The estimates which are appended to this book shew the probable extent to which this system can be extended. In the case of officinalis, half the stem bark is taken in the fourth year, the other half in the fifth year; in the sixth year the bark renewed over the portions stripped in the fourth year is taken, after which the trees are uprooted. In the case of succirubra the periods are similar, but begin and end one year later, the concluding operation being a clean coppice. If however this process is found impracticable from some cause or other, and the choice lies between the coppicing and up-rooting processes, I should recommend the former in the case of robust, the latter in the case of slow growing varieties, when the root bark forms such a large and valuable proportion of the whole.

Value of Ceylon bark.

As to the values of the barks from Ceylon trees under these various circumstances, they can only be determined by analysis; and considering that we have not as yet had satisfactory analyses to shew us what are the best varieties to cultivate, we can hardly hope for early information on such points. There can be little doubt, however, that the enhanced value will be similar to that in India and elsewhere.

Care necessary in barking.

In removing the bark from the living tree, great care must be taken not to injure the cambium, the adjoining bark being used as a fulcrum for the knife, the point of which should not be allowed to touch the stem at all; on the care with which this is done, the success of the renewal entirely depends. Robust trees, such as the large leafed officinalis and succirubra, will be found much easier to deal with than the smaller varieties, and in the case of the latter the very greatest care is necessary.

Barking instruments.

The best instrument for barking is an old blunt prunin

knife, and coolies can very soon be made to use it with considerable skill. The cinchona stripping knives, sold for the purpose, are not as effective; whilst bone and wooden instruments of various shapes, for shaving the bark, which I have tried, have all proved unsatisfactory. There is a patent barking knife invented by Mr. McIvor, of which a diagram is given in his book, I have never seen it in operation, but judging from its construction, fancy it is only useful for barking the smooth even stems found only in theory. Several knives for "scraping" have I believe been designed, which are said to answer their purpose well.

In barking trees that have been coppiced or up-rooted, it is a good plan to saw the stem into 18 inch lengths, after the branches have been removed. This makes the quills of perfectly even length and regular appearance, and the coolies can work with greater ease and celerity. Old succirubra trees, capable of giving the fine large quills so valued by druggists, may be cut into greater lengths, say four feet, and supported on uprights to be barked. All roots should be thoroughly cleansed in running water before barking. Removing barks from cut trees.

The amount of bark that a cooly can take off depends greatly on the weather, the size of the trees, and their health. With large trees, in wet weather, a big task can be done; if the bark is unhealthy, it adheres to the stem, and is very difficult to separate. The following will give an idea of the cost of this work for five year old trees. For *Succirubra*, quill 25 to 35 lbs. per man (large and small together), of green bark; branch from 40 to 45 lbs; twigs, from 22 to 25 lbs; root, about 20 lbs. If the stems are whittled a large quantity can be taken, 50 to 60 lbs., and sometimes over. For *Officinalis*, quill 15 lbs.; branch 35 lbs.; twigs 13 lbs.; and root 18 lbs, are average rates. Cooly tasks.

In *India*, the collection of bark by the method of rooting out, is estimated at 2¼ pies per lb. of green bark, as against 1¾ pies by coppicing, for succimbra. Cost.

In Ceylon for *Succirubra*, the trees being coppiced for the most part, but a few diseased ones up-rooted, the cost of harvesting and curing (by drying in the sun) is 8 cents per lb. dry.

Packing, including cost of waterproof bags R. 1·50 each, with transport to Colombo, may be put at four cents per lb.

Of the cost of the *mossing and renewing* processes in Ceylon not much is known. *Officinalis* appears to cost about 20 cents per lb. harvested by this process; this is when moss is plentiful in the surrounding jungles, a woman

bringing in 40 lb. as a day's task; but when moss is not obtainable, grass may be employed, and reduces the expense greatly. A gentleman in Maskeliya gives the cost of mossing and renewing *Succirubra* at 12 cents per lb. dry, and this proportion is about fair to the rate for officinalis I have quoted.

Renewing suitable. or small acreage.

On a very large scale the stripping and renewing system could not be carried out properly, and I should therefore urge its adoption for the finer portions of a plantation only, and for scattered trees amongst the coffee. If however the scraping process is found a success in Ceylon, and covering the bark is finally decided to be unnecessary, we shall be able to avail ourselves of a system which can be carried out at all times of the year, and not merely at a certain season, and which can consequently be pursued over large acreages.

Value of diseased and dead bark.

The period of approaching decay has been indicated as the time for coppicing or up-rooting the clearing Mr. Broughton's dictum on the subject was that diseased trees contained little, and dead trees no alkaloid. He also shewed that the larger and more vigorous the tree, the more valuable the bark. The result of some experiments in connection with this point, shewed bark from fine vigorous trees yielding 6·76 and 6·94 of total alkaloids; similar trees of the same age, and of mean growth, gave 4·34; and trees of stunted growth 2·40 only; the amount of quinine and the other alkaloids all diminishing in the same proportion. In spite of this, we find no difference in value between the bark of our dying and healthy trees. The reason probably is that the disease is a sudden one, and the tree shews signs of decay, putting on an unhealthy appearance, whilst only certain spots are affected; the bulk of the bark being as valuable as on the thoroughly healthy tree. There is indeed a very generally held opinion, that any thing which arrests the growth of a cinchona tree causes it to increase the secretion of alkaloid, and the change which takes place when the tree is mossed is thus accounted for. Whether there is any truth in the idea or not, it is impossible to say, suffice it, that no proof has been brought forward in support of the theory, whilst the investigations of scientific men do not favour it. Dead bark, that is bark that has been deprived of its juices, and become inert on the living tree, is valueless. Instances have been given of dead bark having a value. This can probably be accounted for by the growth of the tree having been suddenly arrested, by up-rooting for instance, and the bark allowed to dry on it. In this case, there is no more reason for a loss of value in the bark than

if it were stripped and dried in the usual way. This being the case, it is most important that diseased trees should be harvested at an early stage, before any portion entirely loses its vitality; and consequently, coolies should constantly go over the plantation to remove such trees, and to take the bark from fallen branches, &c.

Seasonal Changes.

In India, the value of the bark was found by Mr. Broughton to be greatest in May, before the burst of the S. W. monsoon; immediately following on which is a rapid deterioration during June, which month, with July and August, are the worst. In September, the value rises again, and keeps fairly constant, with a slight depression in January and February, to April. These results are the same in both Succirubra and Officinalis. As might be conjectured, the older the trees get, the less becomes the influence of the seasons on the bark; increasing age, and thickening bark, giving a larger proportion of tissue which remains comparatively quiescent. In Ceylon, January to March will be found the best months for barking; as at the end of the dry season, the separation of the bark from the wood is difficult and expensive, whilst it is of great importance to have dry weather for the subsequent drying and packing.

Bark curing.

In drying the bark, the simplest method is the best, sun drying in the hot weather being least injurious in its effects. The plan of covering the bark with mats to shield it from the sun's rays is bad, as a free current of air, promoting evaporation, is essential; a damp heat being most injurious. Long exposure to the sun is bad, whether the bark be on the tree or not; but it requires exaggerated conditions, such as prolonged and unnecessary exposure, with the bark in a divided state, for the effect to be injurious. The hotter the sun, and the dryer the air, necessitating a short period of exposure, the less the liability to deterioration. It is also evident that the less surface exposed the better, and consequently large quills are less liable to injury than the shreds of bark which are obtained from roots and twigs. Frequent turning of the bark is also a safe precaution. In the last report from Java, a series of analyses is quoted, the method of drying being mentioned in each case. The very slight difference between the bark dried by artificial heat and by the sun, sometimes in favour of the one method, sometimes of the other, shews that the difference is only due to the natural variations between the trees. I may mention that I have stripped large quantities of bark, all of it sun-dried, which from the prices realised could not have suffered any deterioration of moment. When cinchona is grown in con-

junction with coffee, bark spread out in close proximity to the iron roof of the store will be found to dry most satisfactorily. When the stripping process is carried out, or when dying trees have been barked, it frequently becomes necessary to dry in the wet weather. This cannot possibly be done without resort to artificial means ; short periods of exposure to the sun, alternating with exposure to damp air, preventing the bark from becoming thoroughly dry. In this case, I should advise its being despatched to Colombo when half dry, when the completion of the process would present no difficulty. If it is to be dried on the estate, however, the necessary apparatus must be added to the store, which I shall discuss under the heading "Buildings."

Storing bark. Long keeping of bark in a green or half green state impairs its appearance when subsequently dried, but does not affect its value as much as is generally supposed. For three weeks it may be kept without suffering any deterioration whatever. If kept for six weeks, and it becomes mouldy, a slight deterioration amounting to about 0·4 per cent becomes apparent. The alkaloids, under these circumstances, appear very permanent substances, and remain almost unaltered ; while other constituents, such as quinotannic acid, cinchona red, &c., are greatly changed. Even after three months keeping in a moist place, during which fermentation accompanied with spontaneous heating took place, Mr. Broughton found that at least two-thirds of the original amount of the alkaloid was to be obtained from the mouldering mass. Bark carefully dried, and kept in a dry state, suffers no deterioration through keeping.

Packing. In packing the bark for market, it should he remembered that fine stem quills are generally bought by druggists, who give a higher price than the analysis would point to for a fine appearance. Such bark should be packed in cases, so as to keep it whole. As however this method of packing is very much more expensive than when bales or bags are used, it should not be employed except for old bark of even appearance. To further protect the bark from injury, the package should be lined with tarred sacking or some such material. For all other descriptions of bark, which do not depend on their appearance for their value, the double gunny bags, rendered waterproof by tarring, which are procurable in Colombo, are the most suitable packages. For such barks, the system of powdering or breaking into small pieces in a bark mill, which greatly facilitates the packing, has been found successful and does not affect the value.

Messrs. Rucker and Bencraft have given some valuable hints on packing for the market, the price realized seeming to depend to a great extent on the judgment exercised in making up the various lots. In order that a lot of cinchona bark should receive attention from buyers, it should be sufficiently large in quantity to cause them to have portions analysed; and if too small for this, it is bought, in most cases, by speculators for a low figure, who by subsequently bulking a number of such small consignments, sell them at a handsome profit. The smallest quantity that gets fair attention is five cwts., and the more this amount is exceeded, the greater the competition for its purchase. Each package should contain about 105 lbs., and there should be at least six such packages in the lot; the extra 5 lbs. is put in for the purpose of analysis. I have found that a case to hold 105 lbs., quill red bark, contains about 13,230 cubic inches; and if the quills are 18 inches long, and the box made 18 inches broad to contain them, the surface of the side will be 735 square inches, or say 24 inches by 30½ inches. The double gunnies I have described contain about 110 lbs. quill red bark, and about 140 lbs. root, &c., packed by hand, where a hydraulic press is employed, they will of course hold much more. Though it is desirable to have 105 lbs. in each package, it does not appear to be a matter of great consequence. The quill bark should be put in the bale on end, and pieces wedged in between to make the package as compact as possible. All other bark should be rammed into the bale as tightly as possible. When the bale is full to within a few inches of the top, a portion of another bale, which must be cut in pieces for this purpose, should be placed on the top of the package and sewn all round firmly. It is of great importance that this should be done thoroughly, and it will be found that two coolies cannot pack and sew up more than four bales a day properly, at first, at any rate. The use of hydraulic presses for packing is a great saving in many ways, and makes it a doubtful point whether packing by this means in Colombo is not really cheaper.

Messrs. Rucker and Bencraft on the bark market.

On the subject of harvesting the bark and sending it to market, I cannot do better than append extracts from some of Messrs, Rucker and Bencraft's circulars on the subject. In discussing the buying trade, and the best means of meeting their requirements, they write as follows:—

"The buying trade is divided into two main sections, viz., (*a.*) The Druggists, and (*b.*) The Manufacturers. Of these

the last named are by far the most important, and the orders arising from them overshadow the more variable and less constant demand of the Druggists. It will, however, be more convenient for us to consider the nature of these two demands in inverse order to their importance. We, therefore, take first

Druggist Market.

(*a.*) The Druggists.

This portion of the trade may be said to buy on appearance only and with little reference to the analytic value of the bark. They dispose of the bark, when bought, in small lots, chiefly among the Continental chemists, who make from it various infusions, tinctures, and decoctions, and even simply powder it and sell it without further preparation as "Bark," or "Tonic Powders." For purposes of this sort, they do not go to the trouble and expense of analysing the bark to ascertain the real nature of its contents —the smallness of their purchases in many cases rendering the proportionate cost of the process far too heavy—but are content to judge what is presented to them by certain traditional appearances and signs, which, though no doubt originally founded on guiding principles deduced from the results of a number of analyses, have now been warped or altered so far, as to often fail completely, if depended on as guides to the intrinsic value of the bark.

We have, therefore, at the outset to face a somewhat anomalous demand, which puts a fictitious value on the presence of certain conditions, altogether, or at least in great measure, ignoring the richness or otherwise of the secreted alkaloids. It is obvious that this is a state of things which must result in the giving of what may fairly be called fancy prices for Bark of a certain description, and *prima facie* such prices should be eagerly sought after. We will proceed now to explain the peculiarities on which such stress is laid, and then attempt to determine how far it is to the profit of the grower to aim at securing and preserving their presence when preparing the bark for market.

First, as a general principle, it may be laid down that anything which is symptomatic of care in the preparation of the Bark, is accepted as favourable evidence: and evidence of some sort is required by the chemist, not only as to the qualities of the Bark, but also to establish its actual identity. The fact that no analysis is attempted affords great facilities to the passing off of other Bark worked up to resemble Cinchona in taste and appearance, and the first doubt to be satisfied is as to the identity of the Bark. Admitting that to be satisfied, we come to certain requirements for show pur-

poses. Bark is wanted for exposure in the window, and the public have to be convinced of its medicinal properties by outward and visible signs. Again, as the chemist wishes to avoid any elaborate working out of the raw material, he requires Bark which will readily yield enough of its contents to give to his preparations sensible tonic qualities. Lastly,—he wants Bark which, while it fulfils these conditions, does not possess stores of the higher alkaloids which he cannot extract by his rough and ready process, but which would increase the price he must pay.

Reducing these generalities to a more detailed form, we find that the Chemist wants (*a.*) a Bark possessing what is to his mind undoubted evidence of belonging to the tribe of the Cinchonidæ. (*b.*) A handsome bark for show purposes. (*c.*) A Bark which will readily yield a good proportion of its contents, (*d.*) and which does not possess stores of valuable alkaloid useless to him.

It is plain that the Succirubra meets this last requirement better than the more valuable Officinalis. It sometimes happens that the large druggists are obliged to buy Officinalis. When this happens they usually re-sell the Bark, after extracting by their method a part of its contents, to the manufacturer, and it not unfrequently happens that the Bark proves to be just as rich in Quinine as it was before it had been subjected to the treatment of the druggist. His method fails to affect the comparatively insoluble Quinine, while it extracts a proportion of the lower alkaloids. It is obvious then that the chemist does not want a valuable Quinine Bark, but rather a soft red bark, like the Succirubra, rich in total alkaloids, which are separable by his method, but comparatively poor in the obstinate and unyielding Quinine. It is true that even the lower alkaloids are not completely extracted by the process he uses, but they yield to infusion sufficiently to justify him in styling the result a tonic mixture. Its actual medicinal value must vary according to the care and trouble expended on its manufacture—if indeed such a term may be applied to the process—in each dividual case.

As a cheap bark, but yet rich in the more easily separable tonic and febrifugal matter, the Succirubra may then be rightly termed *par excellence* "Druggists' Bark." Nor is it deficient in the other attributes required by them. A larger tree than the Officinalis variety, its Bark shapes into a larger, and therefore, to the uninitiated eye, a handsomer Quill. The appreciation of the quinine manufacturer of the beauty of the deeply marked and scored Officinalis bark would seem to be an acquired taste, and resultant on his

educated knowledge of the properties it contains; for the chemist finds the eye of the public attracted rather by the silvery coated but smooth surface of the stout stem red quill.

We may then accept the fact that not only is the Succirubra bark, at its present price, pre-eminently fitted for Druggists' use, but even if the value of the Officinalis were to decrease, it would still be unsuited for a trade which aims at holding the contents of the Bark *in solution*, and not at working them out into a pure *precipitate*.

With this premise, we may proceed to particularise the points in the appearance of the Bark, the general nature of which we have already determined. They are—

(1.) The boldness and fineness of the Quill.

Stout stem quill, from fully matured trees, is required.

(2.) The regularity of the roll of the Quill.

The double roll finds most favour. It should be uniform throughout, and there should be no knobs or knots in the Bark.

(3.) The length of the Quill,

which cannot be too long, though if otherwise suitable, Quill from a foot onwards in length may be termed "Druggists' Quill"

(4.) The evenness of the Parcel.

This is obviously of considerable importance since it is bought by appearance, but provided there is no absolutely short broken quill, it is of less moment than the conditions mentioned before.

All the points so far alluded to may be classed under the general heading referred to above, as evidences of care in the preparation of the Bark, and they therefore indirectly testify, for the satisfaction of the chemist and his customers alike, to the identity and, as a necessary corollary, to the medicinal virtues of the Bark. Their presence in combination will also go far to secure the value of the bark as a show specimen.

But we have now another point to mention, to which tradition has given a fictitious importance. That is—

(5.) A silvery coating of the epidermis of the Bark, and if possible the presence of crustaceous and stringy lichens.

No doubt the silvered Bark is peculiarly adapted for show purposes, but the value placed upon this condition of the epidermis is too great to be accounted for solely in this way. It is prized rather because tradition has, not altogether unwisely, declared it to be, together with the

bitter taste of the Bark, the great safeguard of the chemist against deception, and the strongest proof of the identity of the parent tree.

We have before us, at this moment, a beautiful specimen of Prime Druggists' Bark, bold, stout, long, well grown, double rolled stem Quill. Its intrinsic value as a Quinine producing Bark is about 3s, but it fetched at public sale no less than 4s 2d. But for some reason or other, though there are evident signs of the existence on it at some time of a complete silvery coating, it has been carefully scraped and denuded of the adherent matter. This was, no doubt, done for some good reason, such as the presence of a parasite, or the mouldiness of the coating, but there is little doubt that its enforced removal depreciated the value of the Bark by a considerable percentage ; indeed, an almost identical specimen, but beautifully coated, realised in a market, somewhat lower in tone, as much as 4s 10d."

I may remark here that we often find in drying quill bark, that the epidermis, and with it the lichens in question, frequently comes off in flakes, leaving the surface of the quill perfectly smooth and dark.

"We see now why, to quote our own words, which were lately misunderstood, stout stem bark , "must never be sent flat to market," for, if so prepared, it would at once lose its chance of realising, on the strength of its appearance, a price far in excess of its intrinsic value.

To ensure its arrival at the home market in the condition we have described, bark likely to command the attention of this portion of the buying trade must be most carefully prepared and packed ; and this opens up the further question as to how far it is to the profit of the grower to attempt to meet the requirements of, and in return command the rates given by this section of buyers.

We have already stated that the Druggists' demand for bark is but a small one as compared with that of the Manufacturers. This drawback is a factor in the question, the importance of which can be, in great measure, accurately determined. But there is a feature in this demand which is apt to upset all calculations ; and that we have already referred to when we called it "variable and less constant." It is impossible to depend on its presence. Orders from abroad may or may not have been received, and in their absence, the finest quill will fetch but its true analytic value, a value which would not have been impaired had it arrived denuded of its silvery coating, flat and in broken chips.

It may be urged that, by holding over bark until the demand is present, this difficulty is easily obviated; but the remedy is not so simple a one as it appears. In the first place, it is a question whether if attention generally was directed to sending over Druggists' quill to market, the amount would not exceed the demand. Further there is the expense of holding the bark to be considered, a slight one, it is true, but still a factor in the calculation. Samples have to be re-drawn and re-distributed, and rent paid. And here again we meet a fact to which we have alluded before, namely, that the buying trade is so small that their favourable disposition is a matter of importance. There is no doubt that there is, on the part of the principal buyers for the Manufacturers, a strong feeling of jealousy towards any large buying in. We do not attempt to defend or even to explain this feeling, but its presence is an admitted fact. In a strong market, no doubt, it can be ignored, but in a weak one, prejudice of this kind may materially affect a sale. If then, after holding over for some little time, in the hope of obtaining the fancy price, a retreat has to be made on the second line of the Manufacturers, it may be found that the movement is not so successful as it would have been if undertaken at first.

However this may be, the variable nature of this demand introduces an element of uncertainty which is not encouraging to those who court it. But if present, it must clearly be understood that it results in distinctly fancy prices. Thus some magnificent Broughton quill, exactly suited for the trade, fetched not long ago 4s. 6d. to 4s. 8d. An eminent manufacturer commenced the bidding at 2s, and we have little doubt that analysis would prove it was not worth to him more than 3s. Again, at the last public sales, held on the 10th instant—some very fine Darjeeling quill realized 4s. 1d. A similar lot, but not so fine in appearance, fetched 2s. 3d., and after the sale the same gentleman we referred to above, told us the two lots gave almost identical analyses. Instances of this sort might be multiplied indefinitely, but we have said enough to shew how materially the value of the bark is enhanced, if it excites this competition."

The extra expense of sending this kind of bark to market is of course a consideration, but it is not great except in the one item of packing; for in any case it is better to take off good stem bark in quill, as there is less loss from dust, and deterioration during the drying process, whilst the difference in the cost of stripping is no great item.

"If then a planter has bark which is likely to shape into "Prime Druggist's quill," we advise him, under ordinary circumstances, to prepare it for market in such a way as to preserve to it the characteristics noted above, and we believe that he will find his enterprise a profitable one. Besides the fine quill bark, the Druggists buy the small twigs, for they most readily yield their contents to unscientific methods. For this reason, twigs must be packed separately, and not bulked with other sorts of bark."

Maunfacturers' Market.

As to the demand of the manufacturers, "it is full of latent possibilities. The consumption of quinine, or failing it, of quinic febrifuges of more or less potency, is capable of vast increase, and that too only by widening the area of their present use: while, on all sides, invention is at work to apply the extracted alkaloids to new purposes.

It is impossible to doubt, when one sees the manner in which Ceylon bark is packed, that considerable misapprehension prevails as to its fate on arrival here. We will briefly describe the history of a parcel from its landing to its sale.

We will imagine a parcel of 50 packages. As a matter of fact, it would probably arrive sorted into eight or nine different bulks, but we will take a favourable instance, and agree that it is separated into five bulks, each consisting of ten packages.

Bulk No. I.—Fine silvered stem quill, suitable for Druggists.

Bulk No. II.—Broken stem quill and chips.

Bulk No. III.—Broken branch.

Bulk No. IV.—Twigs.

Bulk No. V.—Dust and siftings.

On arrival at the wharf, the parcel is sampled as follows:—

(a.) An average sample is made of each bulk, consisting of a small quantity from each package contained in the bulk.

(b.) A sample of 2 lbs. weight is (theoretically) taken from each package. The exceptions to this rule we will explain presently.

These samples are sent to the broker, who proceeds to break up the bark contained in the average sample into as small pieces as possible. and after mixing the broken bark well together, re-divides it into a number of smaller samples, which he sends to the manufacturer to be analysed. The breaking up of the bark into small pieces insures that each

small sample shall be, as far as possible, representative of the bulk, by containing pieces of all its contents, whatever their description.

The second set of samples described above, taken from each package, the broker places, a day or so before the sale, in his show room. The manufacturer, meanwhile, analyses the small average sample sent him, and the result of his test determines the value of the parcel. But he must guard himself against any variation in the bulk, for if he depended on his average sample alone, he might bid for and obtain the first lot of the bulk put up, containing, say five packages, but be outbid for the rest. On examining his purchase, he might find that the portion of his bulk he had secured was decidedly inferior to the remainder, and that the yield of his part of the parcel by no means came up to the promise of the analysis. This danger he guards against by examining the single samples on show at the broker's, noting there any undue variation in the packages forming the bulk.

As a matter of fact, in the case of twigs, small broken branch, etc., the risk of variation in the bulk is so slight that single samples are rarely sent from the wharf, the broker keeping a small portion of his average sample for show purposes. Of course, whenever the bark is likely to be sold for Druggists' purposes, single samples are carefully exhibited. It is not necessary for our purposes to enter into the question of re-averaging by the broker and other minor details, as our object is only to explain the main outlines of the process.

It will be noticed how completely the manufacturer ignores appearance. He receives the bark—though it may be magnificent silvered, bold, carefully rolled quill—broken up until it is a mere collection of chips and splinters. He only takes a cursory glance at it in its unbroken state, to guard himself against a possible loss, but his survey does not alter his estimation of its value. He buys solely on its analysis.

This being so, it will be clear at once to our friends how useless all sorting and separating of any bark, other than Druggists' quill, twigs, or fancy descriptions, must be. We almost invariably receive Ceylon bark laboriously split up into even parcels of broken quill, weaker ditto, bold branch, younger branch, good chips, moderate chips, poor chips, dust, siftings, and so forth. It is impossible to make an average sample of these without re-packing them, for the single parcels would differ too widely, to enable the manufacturer to bid for the separate lots in accordance with the

result of his analysis of the average sample. Now the cost of re-packing is something considerable, and there is always some hesitation felt on the broker's part in recommending it. And its object is only to undo the labour expended unnecessarily on the other side.

It must then be laid down clearly that all sorting of bark preparatory to packing is absolutely depreciatory of the commercial value of the parcel, except in the following cases:—

(1.) Druggists' quill must be kept separate.

(2.) As also twigs, for they are purchased for a separate market.

(3.) It might be well to except any peculiar bark, such as renewed.

The imaginary parcel, then, which we described above, and which, let it be remembered, would in reality have come sorted into twice as many uniform descriptions than we have supposed—ought to be packed as follows:—

Bulk I.—10 packages Prime Druggists' quill.

Bulk II.—30 packages made up of Nos. II., III., and V. above, indiscriminately packed together, viz., broken stem quill, chips, branch, and dust.

Bulk III.—10 packages twigs.

Note the advantages gained:—

(1.) The labour and expense of sorting is saved.

(2.) The loss in sampling is less.

(3.) The manufacturer has one big bulk to analyse instead of three small ones. Instead of this buyer analysing one, and that another, all test the same, genuine competition is secured, and the bulk is of sufficient size to attract universal attention.

But let us investigate further how detrimental to the interests of the seller, and how opposed to the requirements of the buyer, these small bulks are.

A week before the sale, the manufacturer receives numerous samples for analysis. Each analysis costs time and money, and is performed in a reluctant spirit which yields only to necessity. It is obvious that the first parcels operated on will be those that represent the largest bulks, and that there is a margin of value, where the outlay necessary for analysis is no longer induced by the worth of the parcel. That margin is commonly fixed at five to six cwt., and parcels below that size fail, as a rule, to command analysis. They do not offer sufficient inducement to the manufacturer to test them.

The result can but be that they meet with a sluggish competition, which, it may be generally assumed, fails to procure for them their true value."

"With reference to the separation of mossed and renewed bark from other kinds, a few words of explanation are necessary. It is, we presume, needless to say that officinalis bark must be always kept separate from succirubra. The two barks are so different in character—one a relatively pure quinine bark, the other poor in quinine, but rich in total alkaloids—that they are in great measure purchased for different purposes by different buyers. A parcel containing both kinds is apt to fall between the time honoured two stools.

The change in the secretion of bark induced by mossing and renewing is of so marked a character, as to make it advisable to keep them separate in like manner.

It may not generally be known that all East Indian bark fails in respect of one great requirement of the manufacturers, viz., in facile yield of alkaloid. So great a difference do they present in this respect to South American barks, that the most famous tester of Calisaya declared the first immature consignments that arrived to contain no traces whatever of quinine. This peculiarity is exaggerated in renewed bark, and the difficulties it presents to a successful "working out" leads to it being avoided by some manufacturers, the nature of whose operations does not cause the high percentage of quinine obtained to outweigh the difficulties of the process of extraction. This fact also tends to render it advisable to pack it in separate bulk.

Analogous reasoning might be applied to support the separate package of root bark, and in cases where it is possible to make a fair sized bulk of it, it would be well to separate it. Generally speaking, both root bark, and bark which has been mossed and renewed, is so desired by the section of the manufacturing trade of which Messrs. Howard and Sons may be looked on as the chief members, that however small the parcel, healthy competition is induced.

To sum up our notes so far as they have progressed, we may shortly lay down the following principles :—

(*a.*)—The main object to be kept in view in packing bark, is to send large bulks.

(*b.*)—For this purpose pack as follows :—

(1.)—Mossed or renewed bark separately.

(2.)—Root, if in any quantity.

(3.)—Quill, likely to be suited to the Druggists

(4.)—Twigs.

(5.)—All other bark.

(*c.*)—Use as large packages as possible, to save loss in sampling, etc."

The item of shipping and London charges is a very heavy one indeed, and runs away with a large proportion of the value of the bark. The first deduction is one of 3 per cent for dust, which appears to be made in all cases, whatever the kind of bark may be; then follows another deduction of 4 lbs. in every 104 lbs. "tret," and which is no doubt the allowance for analysis and sampling. These deductions reduce the total amount of bark by almost 7 per cent to begin with. Then there is a discount allowance of 2½ per cent on the proceeds of the sale, and a list of "charges;" which comprises freight and interest on freight, landing charges, fire insurance, sale expenses, brokerage 1 per cent, and commission 2½ per cent, with a few other small items. The deductions from the weight of bark and the discount are 9½ per cent off the value to commence with; the "charges" are a tax which weighs heaviest on the bark of least value, and becomes comparatively small on valuable bark. In the former case, they frequently amount to another 15 per cent, or more; in the latter to 10 or 12. For inferior samples of bark therefore a charge of some 25 per cent on the value may be anticipated after the shipment leaves Colombo, whilst 20 per cent will be a safe calculation for bark of good quality. It is to be hoped that with a largely increasing export of cinchona bark these items may be reduced, for at present they constitute a tax of considerable magnitude, and one which it is difficult to bear with complacency. That there are peculiar circumstances in the case of cinchona bark which necessitate a number of charges peculiar to its sale is beyond question, but the 3 per cent allowance for dust in all cases, and the 4 per cent reduction for analysis and sampling, could surely be reduced. The 2½ per cent deduction for discount is of course taken into consideration by the purchasers, still it would be more satisfactory for the growers if this were abolished. The further "charges" which amount in the aggregate to such a large percentage, are unquestionably high, and we must hope that an extension of the trade will cause a reduction. Meanwhile, all we can do is to take great pains with the packing and bulking, so as to make the most of the bark; and make the Ceylon expenses as small as possible. A letter from Messers. Rucker and Bencraft to the *Ceylon Observer*, on the subject of these charges, is interesting in this connection. The explanation given is, in some instances, very meagre and unsatisfactory. The statement that these

deductions are taken into consideration by the buyers has always been self-evident, and does but little to reconcile the producer to them. I make the following extract from the letter in question :—

"The charges and allowances sustained in bringing cinchona bark to market are as follows :—

(1.) Freight.

(2.) Merchant's charges, including commission, Marine and Fire Insurance.

(3.) Broker's charges, including brokerage, public sale expenses, printing, etc.

(4.) Sampling.

(5.) Tare.

(6.) Certain allowances, viz.

Discount	...	2½	per cent.
Tret	...	4	do.
Dust	...	3	do.
Draft	...	2	do.

The first three charges we have enumerated need no comment, since they are incidental to all produce.

The so-called loss from sampling can in no way rightly be called a loss, since it is by means of the samples the whole selling trade form their estimate of the value of the bark, and the more widely they are distributed, the more certain is the seller that he will meet genuine and general competition. As we have often pointed out in our circulars the percentage of loss occasioned by sampling is much greater in the case of small bulks than large. No larger samples are needed for a bulk of 200 packages than for one of 20 packages.

The tare represents the actual weight of the packages and therefore needs no comment.

We now come to the trade allowances, which really constitute, we presume, the grievance of the charge we are considering. We will first briefly describe their nature :—

Tret. This is an allowance of 4 lbs. in every 104 lbs. It is an old West India allowance.

Dust. This allowance of 3 per cent is founded on the fact that a large quantity of dust is lost in the re-packing. The fact that such a loss does take place is beyond doubt, and as we explain more fully below, any excess in the allowance is counterbalanced by a proportionate increase in the price obtained. The allowance for dust may be compared to that of 4 lbs. in 112 lbs. for *garble* in cacao whcih is in theory an allowance for the weight of the husk.,

Draft. This is practically a universal allowance on all articles of produce, and the scale for cinchona bark is in no way exceptionally large, viz:— No allowance for packages under ½ cwt.

1 lb. ..	for packages over ½ cwt and under 1 cwt.	
2 lb. ...	do.	1 cwt. and upwards

2½ *per cent discount.* This allowance explains itself."

CHAPTER III.—BUILDINGS.

The buildings required on a cinchona plantation are fewer and of a simpler character than those on a coffee estate. In most cases a set of lines, of a temporary character, are erected for the coolies engaged in opening the land, the superintendent himself being resident on a neighbouring estate. Or the cinchona clearing is opened in connection with a coffee estate, when no buildings whatever are required in the former. This work would, however, be incomplete without a description of the buildings for habitation necessary on all estates, and of such as would be required for drying and despatching the bark crop. I will, therefore, commence with a brief description of the building materials generally employed in Ceylon, and the work of carpenters and masons, finishing with a few hints for the construction of lines, bungalow, and store. The greater part of the following chapter is taken from the prize essays for 1878, extracts from Mr. Ballardie's being in inverted commas.

When permanent buildings are to be erected, it may be taken as an axiom that the more masonry and less carpentry work that is done the better, and it is to the materials used in the former that we will first give our attention.

Most of the masonry work in Ceylon is of stone, though in some places where it is scarce, bricks are employed. Building stone.

The rock most commonly found in Ceylon is gneiss, it consists of the same materials as granite, namely quartz, felspar, mica, and hornblende, but in a more or less stratified form; it is very useful for building purposes, but is not as strong and durable as granite. The presence of felspar in gneiss makes it red and hard, whilst much mica gives it a grey colour, and makes it not so hard. Quartz rock is sometimes used, but its extreme hardness makes its use in masonry frequently impracticable, it is also a stratified rock; if used, however, it should not be employed for bonding, as it is too brittle. Calcareous rocks, or those in which carbonate of lime predominate, are common, and are very

useful for building, their durability depends on their compactness, and they are very easily worked.

Mr. Ballardie says as follows :—

"The desirable properties in a building stone are that it should be compact, insoluble, not easily affected by the atmosphere, and not liable to take on a vegetable coating. And a simple rule in building, which should have great attention, is, that stratified stones should be laid on their natural beds, for if set on edge they are sure to scale off, and decay under the influence of the weather."

Bricks. The manufacture of bricks requires great care and attention, and a knowledge of the best kind of clay to use is essential. The presence of silicate of lime in clay is bad, as it causes the bricks to soften in the kiln, whilst carbonate of lime in any quantity loses its carbonic acid whilst being burnt, and the quick-lime which remains, by absorbing moisture, causes the decay of the brick. The presence of protoxide of iron, giving a blue colour to the clay, and which turns to red by burning, is beneficial, as it promotes the strength and hardness of the bricks. Sand in moderate quantities prevents the shrinking of the brick ; in excess it makes it too brittle ; one part by volume of sand to four or five of clay is a good proportion. In making bricks, the clay freed from all stones is mixed with half its volume of water, and thoroughly worked until it forms a homogeneous paste ; on the efficiency of this the quality of the bricks depends. The wet clay is then put into moulds, which are about one-tenth larger each way than the brick is required to be, as the clay shrinks in burning. The bricks are then dried in the open air, and burned in a kiln, the temperature being raised to a white heat, and maintained at that till the bricks are sufficiently burnt, when they are allowed to cool gradually. If steeped in water and then submitted to a second burning, their quality is improved. Good bricks should be regular in shape, with sharp edges, and parallel surfaces, should give a clear ringing sound when struck, should shew a uniform structure when broken, be free from air bubbles and cracks, and should not absorb more than one-fifteenth their weight in water. A superior quality of bricks could be made from kaolin, a white clay formed by the disintegration of felspar, which is commonly found in this country.

Lime. Of lime Mr. Ballardie speaks as follows :—

"Generally speaking, it is advantageous to use Colombo coral lime, of which a plentiful supply can always be had for about 50 cents per bushel, slaked. This is richer in

carbonate of lime than ordinary stone. If, however, it be determined to use estate-made lime, care must be taken that, while burning, the stones be brought to a red heat, and maintained at the same till all the gas has escaped, which process will take several hours, according to the size of the pieces of limestone, but the exact time required can only be decided by experience. The smaller the pieces of stone the better; and in building the limestone into the kiln the larger pieces should be placed in the centre, thus allowing them to be exposed to the greatest heat. Where wood is used as the firing agent, about 90 cubic feet more or less according to its nature are required to burn about 35 cubic feet of lime."

Pure lime is made by calcining limestones, consisting chiefly of carbonate of lime; it loses 44 per cent. of its weight by burning, and leaves 56 per cent of its weight of lime. The residue from the kiln in this case is called quicklime, and is remarkable for its violent caustic properties. If left exposed to the air it slacks, or combines with the aqueous vapour, at the same time absorbing carbonic acid to form carbonate of lime, having the same constituents as the pure limestone before burning. To guard against this deterioration, the quicklime should be kept in barrels, in a dry place, until required for use; or it should be sprinkled with water, during which process it swells up, evolves great heat, and falls to a white dry powder, which is slacked lime or hydrate of lime.

To pass into a paste fit for mortar, the powder will again absorb 1½ times its bulk of water, and is then from 3½ to 4 times the bulk of the lime. The hardening of slaked lime is a very slow process, and is caused by the absorption of carbonic acid from the atmosphere, and the crystallization of the carbonate of lime so formed.

Mortar is the binding material used in stone and brick work, and consists of lime and sand formed into a paste with water; it hardens slowly by the evaporation of its moisture, and by the absorption of carbonic acid gas to form crystallized carbonate of lime. Slow evaporation is best, as, if too rapid, the mortar falls to powder. **Mortar.**

The sand for mortar should be clean, sharp, and coarse; if clay is mixed with it, it should be washed in a running stream. The uses of the sand are to diminish the bulk of the lime, and thus save expense; to increase the resistance of the mortar to a crushing force; and to lessen the amount of shrinking during the drying of the mortar. With the ordinary lime prepared in Ceylon, which is by no

means pure, I have found proportions of two of sand to one of lime answer well.

Rubble masonry.

In stone masonry, the following rules are to be observed :—1. The stones are to be laid in a series of courses as nearly as possible perpendicular to the pressure they will have to bear. 2. The joints of one course must each be as nearly as possible in the centre of the stone in the course below. 3. The largest stones must be used for the foundation. 4. To moisten the surface of dry or porous stones, so that the mortar may not be dried too fast, and become pulverised by the stone absorbing its moisture. 5. To make the spaces between the stones as small as possible, but to take care to fill them with mortar. 6. Not to allow the use of any small chips until the final plastering. 7. To see that in every course long stones are used, which shall bind the two faces of the wall together. The reason of these rules is obvious ; if, for instance, the joints between the stones are superimposed one on another, a little abnormal pressure on the top of the wall will cause a crack to extend down it, following the line of the joints ; again, if the two faces of the wall are built separately, the centre being filled with rubbish, (a system often followed by careless and ignorant masons,) one face of the wall will probably give way, and fall down independently on the other. The cost of stone masonry of this description, rubble as it is called, is Rs. 25 per cube of 100 cubic feet, which requires about seven bushels of lime.

Brick building.

In building with bricks, the following rules should be observed :—1. All mis-shapen or unsound bricks must be rejected. 2. The courses or layers of bricks should be perpendicular to the pressure they have to bear, as in stone masonry, and the joints in each course should be on one side of those in the course immediately above and below them, each brick overlapping to the extent of at least a quarter of the length of a brick. 3. Before laying the bricks they should be scraped and immersed in water, so as not to absorb moisture from the mortar too rapidly. 4. Every joint should be filled with mortar, whose thickness should not exceed ¼ inch. 5. No pieces of brick should be used, except to finish off a corner, and then they should not be less than half a brick. The volume of mortar used should be about 1-5th the volume of brick. The terms headers and stretchers have the same meaning as in stone masonry, the former is a brick having its length perpendicular to the face of the wall or pier, the latter has its length parallel to it. The size of bricks is variable in this country ; they are either 12 inches × 6 inches × 2 inches, or 9 inches × 4

inches × 3 inches. The latter is the size usually used for building, and with mortar it is obvious that two headers will occupy the same area as one stretcher on the surface of a wall, including the mortar.

There are two systems of brickwork called respectively *English* and *Flemish bond*. The former is the stronger. It consists of entire courses of headers and stretchers, sometimes placed alternately, sometimes one course of headers only occurring after two, three, or four courses of stretchers. When the wall is required to have great transverse tenacity, courses of headers should predominate; when the tenacity is required longitudinally, the courses of stretchers should predominate. One course of headers, to two of stretchers, forms a wall having equal tenacity lengthwise and crosswise, and is the best in ordinary cases. In *Flemish bond*, a header and a stretcher are laid alternately in each course, and the outer end of each header is made to lie exactly in the centre of the stretcher in the course below. As the number of side joints is the same in every course, there is no difficulty in laying the bricks correctly. A wall of this kind looks neater than one in English bond, but is not as strong. Pieces of hoop iron are sometimes laid flat on the top of the courses, through the wall, to increase its tenacity, the ends being bent down on each side. A cube of brickwork costs about Rs. 58, employs four masons and eight coolies, and requires 1,422 bricks and 8 3-5ths bushels of lime.

Mr. Ballardie writes as follows :—

"In brickwork the whole of the wall should be built up level, to permit it to settle properly; if this be not attended to, rents are apt to take place, as the mortar in drying shrinks. It is also objectionable to carry a wall up any great height at one time, as the heavy weight on that part will have brought it to its bearing before the adjoining parts are built. If it be found impossible to build level at one time, long diagonal breaks should be made. As each course is finished, the mortar should be floated on the top, and care taken that all vertical joints be filled."

The use of cement requires a great degree of skill and attention, for if too much or too little water be used, or if not used immediately it is made, it solidifies unevenly and cracks. A small quantity of water only is necessary to attain the greatest degree of resistance, and the best proportion has been found to be one part of water to three of cement by volume. A small quantity only should be prepared at a time, and should be thoroughly mixed and turned over until used. Cement which is to dry exposed to the air should be mixed with sand to prevent unequal Cement.

drying; the mixture varies from one measure of sand and two of cement, to three of sand and one of cement. An increase in the quantity of sand diminishes the tenacity of the cement; economy, therefore, is the only reason for an admixture of sand to cement which is not exposed to the air, as the greatest tenacity would be obtained by the use of cement alone. When cement is used instead of mortar for brick-work, a mixture of one part of cement to two parts of sand is sufficient; for foundations, or walls in damp situations, two parts sand to three of cement should be used; whilst for works under water, the most satisfactory result may be obtained by the use of cement alone.

In floors exposed to the air, I have found a mixture of equal parts of cement and sand answer well. The thickness of the cement varies from ½ to 1 inch, but the former is of course more economical, and is quite sufficient. I take the following from Molesworth's pocket book:—

	1 in. thick.	¾ in.	½ in.
1 bushel cement alone, or 1.28 cubic feet will cover	1 1/7th sq. yd.	1½ sq. yd	2¼ sq. yd.
1 cement and 1 sand...	2¼ ,,	3 ,,	4½ ,,
1 cement and 2 sand...	3⅓ ,,	4½ ,,	6¾ ,,

Portland cement improves by age, if kept from moisture. The longer it is in setting, the stronger it will be.

At the end of a year, one of cement to one sand is about three-fourths the strength of neat cement; one to two about half strength; one to three, about one-third; one to four, one-fourth; one to five, about one-sixth. Strong cement is heavy, blue grey, slow-setting. Quick setting cement has too much clay, is brownish, and weak.

Bricks, stones, &c., used with cement should be well soaked.

Cement setting under *still* water will be stronger than if kept dry. Salt water is as good as fresh for mixing cement.

The cost of cement ½ inch thick is Rs. 10·50 per square, where two parts sand go to one cement; Rs. 13·75, one cement one sand; Rs. 18 for three cement two sand; and Rs. 22·25 for neat cement. The cost of cement being Rs. 3·50 per bushel.

On the subject of asphalte Mr. Ballardie writes as follows :— Asphalte.

" Asphalte is generally heated in portable boilers ; and when at boiling point a quantity of fine sharp sand in proportion to the quantity of work required should be added. Great care must be taken before applying the asphalte that the surface to be covered be perfectly dry, otherwise it will blister and crack. A bottom of good sand previously heated over a fire to draw out all damp should be spread over the floor ; and as small sections only can be laid at a time, it is advisable to have planed sticks rubbed over with chalk or whiting placed round the part to be laid. Oil is frequently used for this purpose, but the sections of asphalte cannot be got to join so closely with it as with chalk. The asphalte mixture should then be poured in, and smoothed over with a wooden trowel previously rubbed with oil to prevent its adhering. When all air bubbles are expelled, fine sand should be sprinkled over the surface, and worked in with the trowel ; care being taken to fill the air holes not with sand, but with asphalte only. The joints of sections should afterwards be smoothed with a hot iron."

The usual thickness for asphalte is 1 inch, and 4½ cwts. are required per square, which can be laid by one mason, assisted by four coolies. The cost, with asphalte at Rs. 70 per ton, is about Rs. 20 per square.

Concrete is a mixture of mortar with gravel or small stones, and is useful for foundations of all kinds ; it should be about 4 inches in thickness when it underlies asphalte or cement. The best proportions are four of gravel, to a mortar composed of one of lime and two of sand. Concrete.

The cost per 100 square feet is about Rs. 7.

" The best mode of compounding the concrete is to thoroughly mix the lime, previously ground, with the ballast in a dry state ; sufficient water then being thrown over it to effect a perfect mixture, it should be turned over at least twice with shovels, and then wheeled away instantly for use. In every case it should be used hot. Only a sufficiency of water to bring about a perfect mixture ought to be applied, as the concrete should set as quickly as possible, and more water than will just moisten the whole is in excess."

Plastering is the finishing off of the inside of stone or brick walls ; it consists of the application of a mortar, formed by mixing one part of lime to three of sharp live sand. This is laid over the wall to the depth of about ½ an inch, and upon it three coats of lime-white. To render the surface of the plaster smooth, a " float" should be employed ; this is a long piece Plastering

of straight wood, which is worked up and down on the wet plaster to render its surface level.

Shingles. In Ceylon, the large majority of roofs are covered with shingles, for the employment of which there are great facilities on estates, as the materials are on the spot. This style of roofing will last for several years, the exact period at which a renewal is necessary depending on the climate, the nature of the shingles, and the pitch of the roof—that is, on the rapidity with which the moisture is drained off it. Shingles are prepared in two ways, by splitting and by sawing: those used on estates are as a rule obtained from jungle trees by the former method. The best trees for this purpose are Dun, Dawata, Keena, Hora and Madool. But all the shingles in a roof should be of the same description, as otherwise some will become rotten sooner than others. The method of splitting is very simple: the tree is first sawn into the required lengths, the bark and outer sap wood are then cut off, and the logs split up with a large knife made for the purpose, into pieces of the required breadth and thickness. The shingles thus prepared are shaped with a small axe before being used. In the rough, all the shingles should measure at least four inches in breadth, and those with large knots in them, or twisted in shape, should be rejected. This work is usually given out on contract to Singhalese, the rate for splitting being Rs. 5 per 1,000, and for the subsequent trimming Rs. 2·25. The reapers for a shingled roof should be six inches apart, from centre to centre, their breadth being two inches, thus from the bottom of one to the top of the one below it is four inches. Taking the shingles as averaging three inches in breadth, a square of 100 superficial feet requires 800 shingles, and 4 lbs. shingle nails. To finish off the roof, the lowest row of shingles should have six inches of their length sawn off, so as to shew a double row at the bottom; and the ridges of the roof, where different planes of roofing meet, should be covered with a flashing of galvanised iron. A shingled roof should form an angle of 45° with the horizon to last well, but we frequently in practice make the angle less than this. The *sawn shingles* used in Ceylon are usually of *teak*, and are imported from Burmah and elsewhere. Their cost in Colombo is about Rs. 30 per 1,000. The size of a teak shingle is 15 inches by five inches, the upper edge being about half the thickness of the lower. The reapers should be six inches from centre to centre, and each shingle should touch one reaper, and cover the two immediately below it. A square of roofing takes 480 teak shingles.

The method of covering a roof with thatch is a very simple one ; but its employment is not advisable except for temporary buildings, as every year it becomes necessary either to renew it entirely, or to put a fresh surface of thatch on. The pitch of a thatched roof should be 45°; if the slope is less than this, it will probably leak and water lodging will cause it to rot. The cost of thatching depends chiefly on the facilities for obtaining grass, and it is difficult to say what the exact cost should be, but my experience in several cases is that a roof suitable for a set of temporary lines, thatch six inches thick, and frame work of jungle sticks, should not exceed R. 5 per square, when transport of material is the chief item. Thatch.

Tiles are very commonly used for roofing where their transport does not make the expense excessive, and I will shortly describe the method of manufacture. The clay for tile-making requires more care than for brick-making, as it should be purer and stronger. A mixture of sand is sometimes made with the clay, but only when the latter is too strong. For weathering, the clay is spread out thinly in the sun to open its pores, and cause it to absorb more water in mellowing. The clay, thus weathered, is thrown into pits, covered with water, and left for a considerable time to mellow ; it is then passed through the pug-mill, after which all stones, &c., are picked out, when it is again ground. The clay, as it issues from the mill the second time, is cut into lumps, which are staked in a shed ; these lumps are then cut in half, and taken to the pantile table, where the clay is moulded. The tiles are then burnt in a kiln, in the same way as bricks are. Pantiles in this country are usually made with a single curve only ; they vary in size very much, but usually are 15 ins., long, 6 ins., broad at the bottom, and 4 ins., broad at the top. Tiles.

The pitch of the roof for tiles should be an angle of 26½° to 30° : 600 tiles are required for a square of roofing.

In stores, when freedom from leakage is necessary, iron roofing is generally employed. Iron Roofing.

There are three sizes of sheets sold in this country ; those 6 ft. × 27 ins., of which 127 pieces to the ton ; 7 ft. × 26 ins., with 118 to the ton ; and 8 ft. × 26 ins., with 100 to the ton. The first of these sizes is most generally used on estates. For a lean-to roof, the rafters should be 27 ins. apart, and reapers across them 56 ins. apart, on-to which the sheets of roofing are fastened. For a trussed roof the purlines should be 6 ft. apart, common rafters 27 ins. apart, and on them reapers 5 ft. 6 inches apart, the sheets overlapping 6 inches at the ends, and the breadth of one

corrugation at the sides. The sheets are fastened together either by rivets or clips, the former should not be used, as the hole becomes enlarged in time by the expansion and contraction of the metal, and a leak is the result. The latter are curved pieces of hoop iron, which embrace the top, bottom, and lower side of the reaper, where they are fastened with a screw, bend round the top of one sheet of iron, clasping it to the reaper, and by another bend upwards, secure the lower end of the upper sheet, and this without the necessity for drilling any holes in the iron roofing.

A square of roofing requires about 9 of these sheets. and fewer of course of the larger size; the price per ton is R. 310 in Kandy, say R. 330 with transport to estate; which brings the cost of the smaller sheets to R. 23.63 per square. The other sizes differ but slightly in cost. It is a good plan to coat the iron roofing with tar, as this seems to preserve it better from the effects of the weather.

Floors

Next to the construction of roofs, floors are the most important work of the carpenter; their construction in this country, however, is very simple, as they are usually situated on the ground level. The principle upon which wooden floors are laid is always the same; girders are placed across the building from side to side, and resting on piers or whatever may have been built to support them; across these girders, joists are placed longitudinally, and above them again planks, or reapers, are nailed transversely The size of the girders depends on the weight they will have to support, and their length, but the depth should always be greater than the breadth. This applies also to joists, which need only have a sufficient breadth to allow room for the nails.

Where floors are *boarded*, it is always better to have the boards as narrow as possible, as they are then less likely to shrink, warp, or split. The thickness of floor boards is as a rule 1½ or 2 ins. The floor boards are fastened to the joists by floor brads, driven straight through from the surface; or where the boards are sufficiently thick they may be edge nailed, or nailed at the edges in a slanting direction, but this can be done on one side only. Ordinary boarded floors cost about R. 10 per square, exclusive of timber; if tongued and grooved, so that the boards fit into one another, R. 15.

Cost of various works.

Exclusive of the cost of timber, which in most cases amounts only to the cost of sawing and transport, the following are approximate rates for various works connected with buildings from which estimates may be drawn up. A square is 100 square feet, a cube 100 cubic feet.

Rubble masonry	Rs. 25 per cube.
Brickwork in mortar (bricks Rs. 30 per 1,000)	58 ,, ,,
Cement floor ½ in. thick { cement R.3·50 per bus. 1 cement 2 sand. }	10·50 per sq.
,, ,, ,, pure cement	22·25 ,, ,,
,, ,, ,, 3 cement 2 sand ...	18·00 ,, ,,
,, ,, ,, 1 cement 1 sand ...	13·75 ,, ,,
Gravel floor	1·00 ,, ,,
Asphalte. Asphalte Rs. 70 per ton ...	20·00 ,, ,,
Concrete, 4 in. thick	7·00 ,, ,,
,, ,, with lime polished... ...	9·00 ,, ,,
Plastering or rendering. 1 of lime 3 of sand	3·00 ,, ,,
Rendering with floating and setting ...	6·00 ,, ,,
Rendering with rough cast	4·00 ,, ,,
Including everything but cost of timber. { Floor boarded	10·00 ,, ,,
,, tongued and grooved ...	15·00 ,, ,,
Store flooring coir matting ...	19·00 ,, ,,
,, ,, wire matting. Rs. 10 per roll ... ... }	42·75 ,, ,,
Floor brick on edge. Lime mortar ...	22·00 ,, ,,
,, ,, ,, Cement	37·00 ,, ,,
,, ,, laid flat lime mortar	16·25 ,, ,,
,, ,, ,, cement	27·00 ,, ,,
Ceiling cloth	7·00 ,, ,,
Line doors, 5ft. by 2 ft., with frames ...	2·50 each.
Steps for stores, 5ft. wide 10ft. high ...	10·00 ,,
Roofing tiled lean-to. Tiles Rs. 20 per 1000	20·00 per sq.
,, ,, trussed	22·50 ,, ,,
Corrugated iron lean-to. Rs. 330 per ton ...	30·00 ,, ,,
,, ,, trussed	32·00 ,, ,,
Jungle-shingled lean-to { 800 shingles per sq.	17·00 ,, ,,
,, ,, trussed } Rs. 10 per 100 ...	20·00 ,, ,,
Roofing teak-shingled lean-to ... { 480 shingles per square... ...	25·00 ,, ,,
,, ,, trussed } Rs. 35 per 1000 ...	28·00 ,, ,,
Weather boarding feather-edged	4·00 ,, ,,
Trellis work	4·00 ,, ,,
Louvre boarding	14·50 ,, ,,
Partitions, exclusive of timber and plastering—	
4 in. thick	2·50 ,, ,,
6 in. ,, ...	3·50 ,, ,,

In selecting the site for cooly lines some care is necessary, as the health and comfort of the labourers depend in great measure on its suitability. An open commanding site should be chosen, with a good supply of pure water close at hand for bathing and culinary purposes: when possible, a site should be chosen on patena land, so that there can be no difficulty in the way of Cooly lines.

the coolies forming gardens. It is also better to fix upon a piece of level ground for a set of coolie lines, as then no earth cutting is necessary; this rule applies to all estate buildings. The arrangement of a set of lines is very simple: it consists usually of a row of rooms, varying in number from 4 to 10, all under one roof, with a verandah running along one side. It is better, however, to construct double sets, the end rooms opening on to the sides of the building, so that every side becomes a front. The size of these rooms is usually 12 × 12 or 10 × 10, though it varies of course, but the former is a good size for permanent, and the latter for temporary lines. The materials for the construction of lines are various, their suitability depending greatly on the facility with which they are procured. It may be borne in mind, however, that when extremes of temperature are to be encountered, thatch is the best covering; as, being a bad conductor of heat, it will both keep off the heat of the sun in hot weather, and preserve the internal heat in cold weather better than other coverings. The chief objection to its use is the continual repairs which are necessary for its up-keep, as a fresh layer of thatch is necessary every year, even though the whole roof does not need repairing. Where thatch is obtainable, it forms the best material for covering the roof of a temporary set of lines, the construction of which I will first describe. In temporary lines, no sawn timber nor masonry work should be employed, the building consisting of jungle posts only, connected by mud walls, with a roof of smaller sticks and warrachies, supporting a cover of grass. The size of the rooms should be 10 ft. × 10 ft., with a verandah 3 ft. in width, the pitch of the roof being 30°; were the pitch steeper than this, the thatch would last longer, but for a temporary building, where economy is a great consideration, this angle will decrease the cost of the roof considerably. A set of lines of this description should cost from R. 10 to R. 20 per room, according as thatch &c., is near at hand or not. This is exclusive of doors and door-frames, which cost about R. 2·50, exclusive of timber, which has to be provided. Lines of a more permanent description, with pitch of roof 45°, rooms 10 × 12, or 12 × 12, and thatch 8 or 9 ins. thick, will cost from R. 25 to R. 40 per room complete.

The materials for the construction of permanent lines are various, and are generally determined by the facility with which they are procured. Appended is a table shewing the cost of lines in various materials. The rates for most materials have been previously stated; thus bricks are R. 30 per 1000, tiles R. 20, shingles R. 10, &c.; and any difference in the cost of these can at once be allowed for.

Prices for single sets of Lines of Six Rooms.

Materials.	Size of Rooms.	Pitch of Roof.	Cubic feet of brickwork.	Cubic feet of Masonry.	Feet of Timber including Doors &c.	Square feet of Roofing.	Number of Shingles or Tiles.	Number of Bricks.	Total Cost.	Cost per room.
Temporary.										
Six rooms, mud & thatch ...	10 ft. × 10 ft.	30°	...	...	162	9.92	...	...	Rs. 60 to Rs. 120	Rs. 10 to Rs. 20
Permanent.										
Six rooms, mud & thatch ...	12 ft. × 12 ft.	45°	...	...	162	15.12	...	...	Rs. 150 to Rs. 240	Rs. 25 to Rs. 40
Six rooms, 14 ins. brick piers, mud walls, and tiled roof.	12 ft. × 12 ft.	30°	1.12	...	1187	13.32	8,000	1,600	490.91	81.81
Six rooms, 14 ins. brick piers, 12 ins. stone external wall, & tiled roof.	12 ft. × 12 ft.	30°	1.12	8.16	1187	13.32	8,000	1,600	732.99	122.16
Six rooms, 18 ins. stone piers, 12 ins. stone walls, and tiled roof.	12 ft. × 12 ft.	30°	...	10.05	1187	13.32	8,000	...	715.24	119.20
Six rooms, 18 ins. stone piers, 12 ins. stone walls, and shingled roof.	12 ft. × 12 ft.	30°	...	10.05	1187	13.32	11,000	...	675.28	112.54
Six rooms, 18 ins. stone piers, mud walls, shingled roof.	12 ft. × 12 ft.	30°	...	1.89	1187	13.32	11,000	...	433.20	72.20
Six rooms, 18 ins. stone piers, 12 ins. stone walls, and shingled roof.	12 ft. × 12 ft.	45°	...	10.36	1318	15.12	12,000	...	726.73	121.12

PRICES FOR SINGLE SETS OF SIX ROOMS.

MATERIALS.	Size of Rooms.	Pitch of roof.	Cubic ft. of Brickwork.	Cubic ft. of Masonry.	Ft. of timber includiug doors, &c.	Square ft of roofing.	Number of shingles or tiles.	Number of bricks.	Total Cost.	Cost per room.
6 rooms, 18 in. stone piers, mud walls, & shingled roof.	12 ft. × 12 ft.	45°	...	2.20	13.18	15.12	12,000	...	484.65	80.77
6 rooms, 14 in. brick piers, mud walls, & tiled roof.	10 ft. × 10 ft.	30°	1.12	...	9.36	9.92	6,000	1,600	395.41	65.90
6 rooms, 14 in brick piers, 12 in. stone walls, and tiled roof.	10 ft. × 10 ft.	30°	1.12	6.36	9.36	9.92	6,000	1,600	587.83	97.97
6 rooms, 18 in. stone piers, 12 in. stone walls, & tiles.	10 ft. × 10 ft.	30°	..	8.25	9.36	9.92	6,000	..	570.08	95.01
6 rooms, 18 in. stone piers, 12 in. stone walls, and shingles.	10 ft. × 10 ft.	30°	...	8.25	9.36	9.92	8,000	...	540.32	90.05
6 rooms, 18 in. stone piers, mud walls, and shingles.	10 ft. × 10 ft.	30°	...	1.89	9.36	9.92	8,000	...	347.90	57.98
6 rooms, 18 in. stone piers, 12 in. stone walls, and shingles.	10 ft. × 10 ft.	45°	...	8.56	10.76	11.16	9,900	...	583.14	97.19
6 rooms, 18 in. stone piers, mud walls, and shingles,	10 ft. × 10 ft.	45°	...	1.89	10.76	11.16	9,900	...	390.72	65.12

Double Lines—Twelve Rooms.*

Materials.	Size of Rooms.	Pitch of roof.	Cubic ft. of brickwork.	Cubic ft. of Masonry.	Ft. of timber including doors, &c. &c.	Square ft. of roofing.	Number of shingles or tiles.	Number of bricks.	Total cost.	Cost per room.
12 rooms 18 in. stone piers, mud walls and shingles.	10 ft. × 12 ft.	45°	...	2·20	2,948	2,664	21,500	...	1020·79	85·06
12 rooms 14 in. brick piers, mud walls and shingles.	10 ft. × 12 ft.	45°	133	...	2,948	2,664	21,500	2,900	1042·93	86·91
12 rooms 18 in. stone piers, 12 in. stone walls and shingles.	10 ft. × 12 ft.	45°	...	10·72	2,948	2,664	21,500	..	1296·11	108·01
12 rooms, 18 in. stone piers, mud walls and hip shingle roof.	10 ft. × 10 ft.	45°	...	2·20	2,256	2,232	18,000	...	843·53	70·29
12 rooms 14 in. brick piers, mud walls and hip shingle roof.	10 ft. × 10 ft.	45°	133	...	2,256	2,232	18,000	2,900	865·67	72·14
12 rooms 18 in. stone piers, 12 in. stone walls and hip shingle roof.	10 ft. × 10 ft.	45°	...	9·46	2,256	2,232	18,000	...	1060·12	88·34

Mr. Ballardie suggests solid earth walls (without wood) 15 inches thick, as suitable for the construction of lines, also the employment of iron where wood is scarce. He writes as follows :—

"Good tenacious earth (not surface soil) or clay is required for this work. To build walls in this manner, two boards of the length between pillars having been selected and joined, as shewn in plan, by bolts and nuts, are laid in their proper line on either side of the proposed wall; the kneaded earth or clay is then forcibly thrown in; and as the earth hardens, the boardings are removed, by unscrewing the bolts, to the next portion to be done. These lines should cost from Rs. 40 to Rs. 50 per room.

Another style, where wood is scarce, is to build of brick and iron. Stone foundation 1 ft. square, walls of brick and mortar 4½ inches thick, pillars 14 inches square, roof framing of angle iron with tie rods and king posts of common round iron—one on top of each pillar, roof of galvanised iron 24 cwt. Cost of iron framing for roof for single-room-wide set of lines with verandah—Rs. 17 to Rs. 19 each, complete. The only wood-work required for these lines would be wall plates, doors, and door-frames. This style would be permanent and could not possibly take fire. Cost, from Rs. 90 to to Rs. 110, according to cost of carriage. A ventilator between each two rooms takes off the smoke and heated air, rendering the lines more comfortable and healthy. In iron-roofed lines the ridging plate, being raised about two inches from the roof, acts as ventilator."

Bungalow.

The site for a bungalow should be chosen with regard to view, shelter, water-supply, and drainage. It should be situated on the gentle slope of a hill, the front commanding a view of as extended a stretch of country as possible, though shelter from the monsoon winds and rains should be secured at the same time. The disadvantage of a site on the top of a knoll is that it is seldom possible to secure an efficient water-supply in that situation. On the side of a hill, a water course can usually be cut from a neighbouring ravine, which should on no account pass in close proximity to lines, or receive the drainage of a pulping-house, however far away. The drainage of the bungalow should be carefully attended to, and no swamps or damp places should be allowed to exist near it. The best soil is a quartzy or gravelly one, and a stiff clay should be avoided. Trees should always be planted immediately the site is fixed on. The stable and cow-sheds should be a short distance off,

and if possible out of sight. I need scarcely say that cuttings should always be avoided, and a level piece of ground chosen. Temporary bungalows can be constructed at very small cost, where timber is plentiful, of posts supporting a shingled roof, the inside being protected by mud walls, with or without weather boarding. Bungalows of this kind are usually put up on young clearings, and afterwards superceded by a more permanent building. Their cost is from Rs. 300 upwards.

Permanent bungalows are usually built chiefly of stone masonry, sometimes of brick. The main walls should always be of this description, with a coating of plaster ; but some of the thinner partitions may be of mud, carefully smoothed. In climates where timber is exposed to the attacks of white ants, the floors should be of cement or asphalte ; the former if well laid, is the best ; it is cleaner, and looks better. Where boarded floors are laid, they should consist of well seasoned planks, at the most six inches wide, tongued and grooved together, and nailed on joists which are supported by girders. The chief preventive against decay in a wooden floor is a free circulation of air. Iron gratings should therefore be fixed in one or two corners of the rooms, and the space underneath the floor should communicate with the outer air. I have found boards last for many years when thus treated. To improve the appearance of the floor, as well as to guard it against decay, it should be polished with turpentine and bees-wax at least once a week. The ceilings of the rooms and verandahs should be covered with ceiling-cloth, and whitewashed as previously described. Lath and plaster ceilings are seldom seen in Ceylon, and never on estates as far as I know. Boarded ceilings are more expensive, but far better than anything else, and Mr. Ballardie has given some beautifully executed designs for their ornamentation.

Verandahs should be enclosed by trellis-work, about three feet high, along which creepers should be trained ; above this point it is better left open. When the sides of verandahs are exposed to the weather, as is frequently the case, they should be boarded. Creepers should on no account be allowed to grow over the roof, as their stems, enlarging by growth, move the shingles and cause the roof to leak. All timber exposed to the weather, such as verandah posts and trellis-work, should be painted or varnished.

The style of roof to be erected depends entirely on the shape of the building : when it is rectangular in shape and

compact, a high roof on the centre walls, continued beyond them to protect the verandahs is the best. Several materials are used as coverings to the roof, of these shingles are the most common, and doubtless the best. Split shingles are generally employed, and last well, where the pitch of the roof is steep. Teak sawn shingles do not form as water-tight a covering as split shingles ; they make a much neater looking covering, but invariably leak, and this fault appears to increase with time. The lasting quantities of split shingles cannot be compared with that of teak sawn shingles, but, putting appearance aside, the balance is decidedly in favour of the former.

Tiles are sometimes employed, where they are close at hand, and make a very good roof.

Metal is seldom used on account of the extremes of heat by day, and cold by night, which it causes. This may be obviated in a great degree by the interposition of felt under the metal, but the expense is then very great.

To keep a bungalow dry, fire-places with chimneys, or stoves should be erected, except in very hot climates. The former are preferred by many people on account of the cheerful homely appearance a good fire gives to a room ; the latter are becoming generally used, and are more convenient than the former in many respects.

The construction of a chimney requires a little care. The flue should be of the same size all the way up ; say, about 1 foot square. The fireplace being about 2 feet 9 inches wide, 1 foot 6 inches deep, and 3 feet 6 inches high. The sides of the fireplace should be farther apart in front than at the back, and the flue should get narrower gradually until it is the minimum size, which dimension should be continued to the top. In windy situations, a cowl of one kind or another should be placed on the top of the chimney to prevent the smoke being blown down it.

There are several operations for plastering, which have not been previously described, as they are employed solely for finishing off the walls of bungalows. Rendering and floating has been considered under the heading masonry, as the walls of most buildings are finished off in this way. To obtain a fine surface above them, "setting" is laid on. This is made of pure lime mixed with sufficient water to bring it to the consistency of cream. It is then allowed to settle, and the superfluous water poured off. When the plaster is about half dry, this is laid on with a trowel, and alternately wetted with a brush and smoothed, until a fine surface is obtained. When an outer wall is to be painted, it is coated

with stucco, composed of setting, as just described, and sharp sand. This is alternately wetted and smoothed with a trowel, until it becomes very hard and smooth.

Rough-cast is another method of finishing outside work, by dashing over the coat of plaster while still wet, a coating of rough-cast, composed of sharp gravel, mixed with lime and water until it is in a semi-fluid condition. As has been shewn before, rendering costs about Rs. 3 per square; with "floating" and "setting," it will cost Rs. 6 per square; if rough-cast only, Rs. 4 per square.

The rooms of bungalows are frequently divided off by wooden partitions. These may be constructed of upright posts, say 3 ins. × 3 ins. and about 1 ft. apart, with horizontal laths 2½ ins. × ½ in., nailed along them on either side, the interstices being filled with mud, and a coating of plaster applied outside. The cost, exclusive of timber and plastering, should be about Rs. 2·50 per square if 4 ins. thick; Rs. 3·50 per square if 6 ins. thick.

As a rule, it is unnecessary to construct a drying house for cinchona bark, there being a coffee store or some such building available in the vicinity. If not, the plan of building substantial permanent lines at the beginning with a view to their conversion into a store when necessary might be followed. When practicable, this method is a good one. I will, however, describe briefly what appears to be the best form of building. **Store.**

The most suitable arrangement would be that of a long narrow building, fitted with rows of racks to hold moveable trays, and covered by an iron roof supported on 18″ piers 8 ft. apart, the breadth being 20 ft. internally, and the height to wall plate 10 ft. The length depends entirely on the amount of bark to be harvested. This breadth will allow of 4 tiers of trays, 3 ft. wide, one along each row of piers at the sides, and two along the centre of the building, separated from the side tiers by two passages, 4 ft. wide. These passages will thus each have a tier of trays on either side, their width being sufficient to allow of the trays from one tier only being removed at a time. There is no necessity to close in the sides of a bark store, as robbery is not to be feared, but the roof should project beyond the sides sufficiently to shelter the inside from rain, and louvre-boarding be carried up to a height of 5 feet or more in an exposed situation. In a wet district, it might be necessary to dry the bark on the clerihew system, or by means of stoves to heat the building, the walls of which would then have to be closed in; but it is always better to dry in the sun when possible; besides which, as has been before shewn, the dry season is the best for barking,

a small amount of bark from dying trees only being taken during the wet weather.

At the end of the building there must be a room for the purpose of packing the bales in, or the centre rack for trays might be so constructed as to be easily taken to pieces and removed, which would allow ample space for this.

The building being 10 ft. high, there may be 24 rows of trays, 5 ins. apart, in each rack, or 96 rows in all: were the building 40 ft. long, this would give over 11000 square feet of surface on which to spread the bark for drying, which would be sufficient for taking in the crop from a fairly large plantation.

The floor of the building should be of cement, and the trays of bamboo, so that the dust will all fall to the floor during the drying of the bark, and be then collected. A building of this kind, with iron roof, stone masonry piers, with louvre boarding between, cement floor, and including 960 bamboo trays 4 × 3 ft. with racks &c., would cost about Rs. 1200.

A large barbacue would be necessary near the store, so that every advantage might be taken of sunshine to expose the trays.

PART V.

DISEASES AND ENEMIES OF CINCHONA.

Canker from damp soil.

There are very few diseases to which Cinchona is liable, that known as canker being the most common. This disease has been spoken of as being due to "unsuitableness of soil, unpropitiousness of climate, or want of access of air." It is not infectious in any way as are "rust" in wheat, or leaf-disease in coffee, but being generally seen to affect patches of several trees at a time, the idea is not uncommon that it is infectious. In the case of cinchona, one form of it arises from the roots of the tree encountering a damp sub-soil, and occurs at all stages of the growth of the tree. When the dampness of the soil is extreme, the plants when young make little growth, the leaves become yellow and unhealthy, decay sets in, generally from the root upwards, and the plant dies. If a damp sub-soil exists at some little depth the trees grow healthily for several years, and then suddenly commence to die off in the way described. This is often seen in trees planted near damp ravines, the disease spreading upwards year by year, as each row of trees in turn send their roots sufficiently deep into the soil to encounter the damp sub-stratum. In all these cases, disease first attacks the roots, its existence manifesting itself in the first instance by a discolouration of the leaves, which fall off, gradual shrivelling of the cortical and woody tissues then takes place from the root upwards, and the tree dies. A sure sign of excessive damp in the soil is the shrivelled appearance sometimes assumed by young plants; though of a healthy colour, the leaves shrink inwards towards the stem, and the primaries shew a stunted growth, and this is noticeable for some time before decay sets in.

True canker.

There is another form of canker, by some considered a separate disease, which manifests itself on the bark of the tree first. It appears in patches, as if some acid had been dropped on the bark, which becomes shrivelled and brittle. These patches sometimes extend horizontally, and sometimes vertically, destroying the tissue of the bark, which assumes a red colour, and adheres firmly to the wood of the tree. The sap, which in a healthy tree is almost colourless, becomes thick and of a yellow colour, through fermentation

in the cells, which split and become disorganised. The decayed bark dries up and contracts, the sap ceasing to circulate in it, whilst the deposit of wood goes on above. This produces a swelling above the diseased part. The roots are also sometimes affected by this disease. The decayed portions of the bark are generally found to contain the filaments of a minute fungus, which occasionally penetrate into the living tissue; this is in no way the cause of the disease, but one of its attendant effects. It is probable that the fungus gains sufficient nourishment from the decayed bark to penetrate into the living tissue, but only when the cells of the latter have become, to a certain extent, disorganised by the disease.

Probable causes. It is often found that trees into whose stems water has entered, either through a wound, or through the junction of the stem with a branch that has died, or been clumsily cut off, are affected by a disease of the pith accompanied by the usual appearances of canker in the surrounding bark. It is also noticeable that this disease usually develops itself a day or two after the commencement of a spell of dry weather, remaining more or less dormant during the preceding rains. It therefore appears likely that the second form of canker is attributable to the presence of too much moisture also—probably in the atmosphere, in this case—inducing a superabundance of moisture in the bark, which stagnates, and causes a decomposition of the contents of the cells, the evil effects of which develop themselves on the occurrence of a change in the inducing circumstances: but the subject offers a field for further investigation, and is very obscure. This reasoning is, however, borne out by the fact that the districts of Ceylon, remarkable for the dryness of their climate, and the openness of their soil, are comparatively free from canker in any form; whilst Mr. Moens reports that the disease is very seldom seen in Java.

Some authorities attribute canker to the effects of "hard propagation," considering it to be a disease attacking plants that have become liable to it from a weakness derived from the parent tree, which has been forced to yield an excessive and unnatural number of cuttings, seeds, &c. I do not think this theory can be accepted, for the disease is apparent in all species alike, though the commoner kinds have not been forced into yielding as the rarer kinds have; besides which, the disease is said to have been found in damp situations in the forests of the Andes.

Alkaloids in cankered bark. Mr. MacIvor has found that the alkaloids entirely disappear from cankered branches, which die and dry on the tree while in a growing state. This is a most curious fact,

and all the more interesting as it is not limited to diseased bark, and seems not to be caused by the disease. When a tree in perfect health is destroyed by a ring of its bark being artificially removed from the stem, and the circulation thereby impeded, the tree gradually dies. In this case also, the alkaloids gradually disappear in exactly the same way as in a tree which dies from canker. He found that as soon as a plant began to decay, whether from disease, or from being artificially ringed, the alkaloids began to disappear; or rather, in the first instance they became more or less uncrystallizable. It is only when the bark becomes quite dead on the living stem that all trace of the alkaloids is lost. This is the more curious, as mere dead bark does not part with its alkaloids by being kept for any length of time, or apparently in any climate. The cause therefore of this dissipation of the alkaloids must be that the living leaves of the plant draw the whole of them from the dying bark; whilst the disorganisation of the cells, whether from disease, or from the incipient death caused by ringing, prevent the return of any of the alkaloids to the bark from the leaves. This conclusion is partly confirmed by the fact that if a tree be felled, and the bark allowed to dry on the stem, it retains its alkaloids, and may be preserved in this state for any length of time.

These results appear to shew the fallacy of the idea that checking the growth of the tree increases the richness of the bark; whilst, as said before, there is absolutely no proof of this being the case. It has been stated that the bark of diseased trees is as valuable as that from healthy trees, and this is the case if it is harvested in time, for the diseased patches form but a small proportion which should not be taken, the balance being perfectly healthy.

Treatment of cankered trees.

In the first case, where the disease spreads from the root upwards, the only remedy is to uproot and bark the tree before the spread of the disease has rendered all the bark more or less worthless. In all other cases, the disease is arrested, at any rate for a time, by cutting down the tree below the point of attack, a healthy shoot being the usual result.

Cutting out the diseased piece might be successful, were it not that decay would probably be induced in the spot operated on, if the sap wood, into which, as I have shewn, the disease extends, were cut. Besides which the points of attack are frequently so small as to make the method impracticable on a plantation of any size.

It would, of course, be sufficient to cut the tree immediately below the point of attack, but in practice it is found

dangerous where the work is being carried on on a large scale, as some unnoticed centre of disease is likely to be left below the severed place, by the coolies entrusted with the work, which may spread and kill the tree. A severe attack of canker always affects the appearance of the tree, and the best method in practice is to send coolies over the plantation periodically, with instructions to uproot all trees which shew signs of canker on the stem bark near the ground, and to coppice those which are affected higher up only, and from which healthy stools will be left. They should also uproot all the stumps of trees previously coppiced that shew signs of dying. The term "canker" is generally applied, in Ceylon at any rate, to both the diseases, or forms of disease which have been described; although in the one case it arises solely from contact of the roots with a damp sub-soil, in which case it is undoubtedly fatal. It would certainly be less confusing if the distinction made by Dr. King were adopted, and the term applied only to the second form of the disease when it is purely local, and by no means invariably fatal. In the latter case all parts of the tree except those actually attacked by the disease are healthy ; and there appears to be no reason against propogation by cuttings from it.

Remedies for canker.

As to the prevention of the disease which arises from damp in the soil, draining is the remedy that at once suggests itself. When imperviousness of the sub-soil is the cause, draining is utterly ineffectual; if the surface soil alone is stiff, and there is no impervious sub-stratum, close and deep draining has a beneficial effect. Liming and forking the soil has been tried but without much effect; manure or rotten vegetable matter, loosening and warming the soil, has been found of benefit.

The form of canker to which the term is most applicable, and to which it ought alone to be applied, is of such obscure origin that no remedy can be suggested for it. Suffice it, that it is more commonly found in wet than in dry climates. The disease which is caused by the wash of surface water against the stem, or by its stagnation in hollows round the collar, is of course preventible by draining, or proper sloping of the ground. In this case, it is none the less a true form of disease, though it arises from the mechanical action of water. To prevent this, it has been suggested to heap earth round the collar. In India, according to one of Mr. McIvor's reports, this has been found to be the cause of the death of many previously healthy trees. For when the stems are covered for an inch or two above the collar with earth, a fungus attacks the bark, particularly in wet weather, which

destroys fine plants of two or three years growth in a few days. This has been alluded to before. Small semi-circular drains above the trees are thoroughly effectual and much safer.

Canker in nursery plants.

In small nursery plants a kind of canker is often noticed, evidently arising from an excess of moisture, which attacks the stems at the point where they enter the ground. Such plants should not be put out in the clearing, and more thorough draining and barrelling of the beds should be resorted to in the nursery. The cause of this disease is frequently an excessive elevation above the mist line in a damp climate, and it is advisable to remove the pricking out beds to a lower elevation. The seed beds are not generally attacked in the same way.

Many of the failures of planted clearings are probably attributable to this cause ; for, except in the spot indicated, and from thence to the roots, the plants frequently shew no signs of disease at first.

Hide-bound trees

" Hide-bound" trees are sometimes met with, the disease being frequently taken for canker. It is however an entirely distinct affection. A vertical slit in the bark is said to relieve the tree.

The Java pest.

In Java, the cinchonas are exposed to the attacks of an insect belonging to the Hemiptera, which cause the so-called red spider in tea-bushes. "The full-grown winged insect, as well as the young wingless individuals, feed on the sap of the young leaves, and of the young portions of the bark, making punctures in the epidermis of these parts with their proboscis, whereby the green tissues acquire a spotted appearance. Upon the further development of the leaf, the uninjured portions grow at first, whilst the wounded portions become speedily brown, as if the leaf were dead, and the growth of it is wholly destroyed. The consequence is that the leaves and young shoots die, and when, as is mostly the case, the greater number of the shoots are attacked, the growth of the tree is retarded for some time." It does not appear that we are exposed to the attacks of this insect in Ceylon fortunately, but we have a worse enemy in the green caterpillar. This is the larva of a hawk moth, nearly allied to the oleander moth, and is of a bright green colour with spots on its sides. These caterpillars appear very suddenly, and grow rapidly to a large size, eating an almost incredible amount of leaf. They also attack the young shoots of the trees, when the leaves are finished. One gentleman calculates that he has 200 eggs of this moth on each tree, and suggests the application of some poison to destroy their vitality. Had we a suitable preparation, this would certainly be the best way to get rid of the pest, but as yet their des-

The green caterpillar.

truction in this form is a matter of experiment. These attacks will generally be found to be periodical, though a few caterpillars are always present. The worst attack is generally in the hot weather in January, February, and March, and decreases until the burst of the South-West Monsoon, when there are but few to be found. Being thus periodical, their attacks can be anticipated. The only plan is to send boys round the clearing when they first appear, to pick them off the trees, and to keep a gang constantly at work until they disappear. The chrysales are often to be found just below the surface of the ground near the stem of a tree. When the cinchona attains a large size, their attacks become of little moment; it is to young and sickly trees that they are so destructive. Succirubra is more liable to their attacks than officinalis.

Black grub.

There is also a black grub which nips through the stems of young cinchona plants, and is usually found just under the surface of the ground, in close proximity to the plant attacked. It has been suggested that an admixture of unslaked lime to the soil in the hole before planting will destroy this pest. A grub, which attacks the bark of matured trees, is thus described by a correspondent of the "Ceylon Observer":—"I can safely say that more than half the trees that I have found on this estate dying have been caused by a grub which eats the bark just above the root, and about from 3 to 4 inches below the soil. This grub generally eats (at least so I find) about a quarter of the circumference of the tree, sometimes less; the ring or rim that he eats is sometimes as broad as half an inch. The grub itself is of a light brown colour, and is very strong and tenacious of life."

Sambur.

Sambur and other wild animals are often found very destructive to plantations of officinalis, by eating the tops of the trees off, but they do not appear to touch succirubra plants.

White Ants.

In some districts, cinchonas are liable to the attacks of white ants, which in one instance are reported as having tunnelled the whole of the wood, leaving the bark intact; it seems probable that the tree was in a state of decay previous to this attack. The best antidote appears to be the application of diluted paraffin oil, one wine glass full to a bucket full of water, a measure of the mixture being applied to each tree.

Black and white bug.

The black bug and white bug of coffee are also amongst the enemies of cinchona, but to so small a degree in Ceylon as not to be worth attention. In India the former is reported as having attacked cinchona severely, but only when the trees were planted amongst coffee always liable to its attacks.

Borers of different kinds attack cinchona trees both in India and Ceylon. Their attacks are not to be feared however. Plugging up the hole by which they enter is advised, when their destruction is certain ; or they may be killed by the insertion of a wire into the hole. Borers.

In Ballangodde, the ledgerianas are reported as being liable to a disease of the leaves, for which an application of lime and sulphur is found effectual. Disease of the leaves.

In the nurseries, the seedlings are exposed to the attacks of several enemies. Amongst these the white grub which attacks the roots, crickets, and various beetles that nip off the tender shoots, and a small brown ant-like spider. A mixture of kerosine oil and water, one of the former to eight of the latter, is reported as proving an effectual remedy.

Nursery plants are also liable to the attacks of a fungus, but this portion of the subject has been treated of under "nurseries."

Appended is an extract from the "Madras Times" containing a description of a new enemy to cinchona seedlings :—"The brown fringe like substance growing on the cinchona leaflets is a curious fungus growth. The parasite is attached to the hairs of the cinchona, and consists of a net work of fibres and large numbers of spores, the equivalents of seeds in flowerless plants such as fungi. The fungus growth on each hair forms a clublike body, quite distinguishable by the naked eye. Owing to the large number of spores, the fungus, if once introduced into a nursery, would spread rapidly. The cause of this disease, for so it may be called, is likely excess of damp. The nursery in which the seedling grew is probably badly drained or too much in the shade." Fungus attacking seedlings.

There is also a small green weevil that eats the leaves of cinchona as well as coffee, and which is thus spoken of in Neitner's "enemies of the coffee tree.":— Green weevil.

"This pretty beetle is common during the dry weather, but I have never found it do any injury to the coffee. Mr. James Rose, of Maturatta, who first directed my attention to it, wrote to me : 'The mischief they do to the coffee is really frightful, and if they were as plentiful as the bug, they would be our worst enemies. Five or six acres were completely covered with them, and they consumed almost every leaf. Year after year, they appeared upon the same place. This year they appeared upon a neighbouring estate in great force, and ran over at least forty acres. The same thing occurred on three other estates.'

The family of these weevils is one of the most extensive amongst the beetles, and many of its members both here and in Europe do much injury to agricultural produce." Applications of lime would probably prove an effectual cure.

PART VI.

CINCHONA OFFICINALIS.

Estimate of expenditure and returns on 100 acres officinalis, planted 3½ × 3½, with 3,500 plants to the acre, and opened from an adjoining estate.

NURSERY.

Nursery for 100 acres officinalis planted 3½ × 3½, opened January, 1879.

1st Year 1879.

Eight lbs. Indian seed at Rs. 5 per lb. ...	40
Opening and cost for one year	960
Total Rs....	1,000

Plants costing Rs. 10 per acre.

2nd Year, 1880.

Two lbs. Indian seed at Rs. 5 per lb. ...	10
Up-keep of nursery	290
Total Rs...	300

Plants for supplying will cost Rs. 3 per acre.

3rd Year, 1881.

Two lbs. seed and up-keep as before Rs...	300

Plants for supplying at Rs. 3 per acre.

To open 100 acres of cinchona officinalis, and plant during N. E. monsoon, December 1879, to March 1880. Planted 3½ feet × 3½ feet with 3,500 plants per acre.

Cost of 100 acres land,	at Rs.	150	per acre.	15,000
Nursery	,,	10	do.	1,000
Superintendence ...	,,	15	do.	1,500
Survey fees	,,	2·50	do.	250
Felling and clearing ...	,,	20	do.	2,000
Roads 4 miles ...	,,	110	per mile	440
			Carried forward...	20,190

		Brought forward...		20,190
Draining ...	Rs.	7·50	per acre	750
Lining, cutting pegs, &c.	,,	8	do.	800
Holing and filling in	,,	20	do.	2,000
Planting, supplying, shading,	,,	25	do.	2,500
Tools				300
Lines, (1 set, 6 rooms 12 ft. × 12 ft. Rs. 80)				480
Contingencies (Medical Assessment, &c.)				250
Weeding, 9 months at 75 cents ...				675
		Total Rs...		27,945

Cost of opening per acre Rs. 129·45.

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100 acres cinchona officinalis is planted. The following shews expenditure to end of 1st year. From April 1st 1880, to March 31st 1881.

1880-81.—1ST YEAR.

Superintendence	Rs.	1,000
Nursery at Rs. 3 per acre	,,	300
Supplying and shading 25% say at Rs. 5	,,	500
Weeding at 62 cents	,,	744
Suckering, picking caterpillars, &c. ...	,,	100
Up-keep and improvement of roads and drains		250
Contingencies	,,	206
Total Rs...		3,100

or Rs. 31 per acre.

Season April 1881, to March 1882, or plants *two years old.*

1881-82—2ND YEAR.

Expenditure as before	Rs.	3,100
Staking, say 25 acres, at Rs. 20 ...	,,	500
Total Rs...		3,600

or Rs. 36 per acre.

Season April 1882, to March 1883, or plants *three years old.*

1882-83—3rd year as before ... Rs. 3,600

100 acres cinchona officinalis, April 1883 to March 1884, or plants *four years old.*

1883-84.—4TH YEAR.

Superintendence	Rs.	1,500
Weeding at 62 cents	,,	744
Up-keep of roads and drains ...	,,	250
Buildings, repairs, additions to lines	,,	500
Contingencies	,,	186
Up-rooting and peeling diseased trees, say 25% per acre at 6 ozs. dry bark per tree, say 33,000 lbs. bark, costing 14 cents per lb. (including 330 water-proof bags at 1·50 cents each, packing and transport charges to Colombo)	,,	4,620
Total Rs...		7,800

Season 1884-85, or 5th year, same as above Rs. 7,800

100 acres officinalis, of which half the trees have been taken out, April 1885, six months expenditure 1885, *five and a half years old.*

Superintendence	Rs.	1,000
Weeding	,,	372
Up-rooting balance of trees, 50% at ½ lb. dry bark per tree, giving 87,000 lbs. bark at 14 cents per lb. as before ...	,,	12,180
Contingencies	,,	248
Total Rs...		13,800

Summary.

	Cost of land with opening and expenditure for 5½ yrs. or from commencement of nursery, 6½ years.	Value of produce from 100 acres officinalis so opened.
To March 1880.		
To opening 100 acres with cost of land	Rs. 27,945	—
1880-81 To expenditure ...	,, 3,100	—
1881-82 ,, ,, ...	,, 3,600	—
1882-83 ,, ,, ...	,, 3,600	—
Carried forward ...	38,245	Nil.

	Brought forward...	Rs. 38,245	Nil.
1883-84	To expenditure ...	„ 7,800	
„ „	By sale of 33,000 lbs. dry bark at 3*s*. per lb. with 10 % added for exchange ...	—	54,450
	Freight, insurance, and all home charges on above at 20 % on value	„ 10,890	
1884-85	To expenditure ...	„ 7,800	
	By sale of bark as before	„ —	54,450
	To home charges „ „	„ 10,890	
1885	To six months' expenditure	„ 13,800	
	By sale of 87,000 lbs. dry bark at 3s. per lb. with 10 % added for exchange ...	—	143,550
	To home charges 20 %	„ 28,710	
	To purchase of Land and expenditure ...	„ 118,135	
	By profit ...	„ 134,315	
		Rs. 252,450	252,450

Or Rs. 1,343 profit per acre, an allowance of 15 % for exchange, instead of 10 %, would increase the profit per acre to Rs. 1,434, say £122 sterling per acre.

We now have the land free, and all planted by self-sown seedlings, or suckers if any of the trees have been coppiced, one-fourth being 2½ years old and so on. The next cutting would take place in May 1886, and each succeeding year.

I will now give an estimate of a plantation harvested in the way recommended for officinalis, by a combination of the stripping or scraping and uprooting processes. The method is only suitable for the finest portions of a clearing, and would be difficult, if not impossible, to conduct on a very extensive scale, unless it were found that the trees renewed their bark with certainty without any covering. This being a condition which is not the case everywhere, allowance has been made for the performance of the process in the ordinary way, with a covering of moss, or other material, on a small portion of the plantation only. The data upon which this estimate is framed are not as satisfactory as in the previous case, but will, it is hoped, be found not far wrong.

10 acres of officinalis opened as before in 1879-1880.
To March, 1880.

Expenditure at same ratio as before, viz., Rs. 279·40 per acre	Rs.	2,794

1880-81.—1st Year.

Expenditure at Rs. 31 per acre ...	„	310

1881-82.—2nd Year.

Expenditure as above without staking, at Rs. 31 per acre	„	310

1882-83.—3rd Year.

Expenditure as before	„	310

1883-84.—4th Year.

Superintendence, weeding, &c., &c ...	„	318
Stripping and covering 35,000 trees, taking 1 oz. dry stem bark per tree, or 2,187 lbs. at 20 cts. per lb.	„	437
Packing and Transport to Colombo on same at 4 cts. per lb.	„	87
	„	842

1884-85.—5th Year.

Superintendence, &c., as before ...	„	318
Stripping off the covered bark not taken the previous year, 1½ oz. per tree, or 3,280 lbs. at 20 cts. per lb... ...	„	656
Packing, &c., at 4 cts...	„	131
	„	1,105

1885-86.—6th Year.

Taking the renewed bark formed over the portions of stem denuded in 1883-84, say 2,187 lbs. renewed bark with expenditure as before	„	842

1886.

The trees have now say 3 oz. renewed stem bark, and from April 1886 are uprooted. 6 months' expenditure 1886, trees 6½ years old.

Superintendence	Rs.	100
Weeding	„	37
Contingencies...	„	24
Carried forward...	Rs.	161

Brought forward ... Rs. 161

Uprooting 35,000 trees at 6 oz. dry bark per tree (3 oz. renewed stem and 3 oz. root and branch) say 13,125 lbs. at 14 cts. per lb. to include all charges to Colombo as before ... ... Rs. 1,837

Rs. 1,998

To March,		All expenses for 6½ years, or from commencement of nursery 7½yrs.	Value of produce from 10 acres officinalis.
1880	To opening 10 acres with cost of land ..	Rs. 2,794	
1880-81	To expenditure ...	„ 310	
1881-82	„ „ ...	„ 310	
1882-83	„ „ ...	„ 310	
1883-84	„ „ ...	„ 842	
	By sale of 2,187 lbs. of natural bark at 3*s.* per lb. with exchange ...	—	3,608
	To home charges on above	„ 721	
1884-85	To expenditure ..	„ 1,105	
	By sale of 3,280 lbs. of covered bark at 3*s.* with exchange ...	—	5,412
	To home charges ...	„ 1,082	
1885-86	To expenditure ...	„ 842	
	By sale of 2,187 lbs. of *renewed* bark at 6*s.* per lb. with exchange ...	—	7,217
	To home charges ...	„ 1,443	
1886	To six months' expenditure	„ 1,998	
	By sale of 6,562 lbs. of *renewed* at 6*s.* ...	—	21,654
	„ „ *natural* at 3*s.*	—	10,827
	To home charges on above	„ 6,496	
		Rs. 18,253	
	By profit	„ 30,465	
		Rs. 48,718	48,718

Or Rs. 3,046 per acre, the land being planted with self-sown seedlings as before, though not so old as in the previous case.

CINCHONA SUCCIRUBRA.

Estimate of expenditure and returns on 100 acres succirubra, planted 5′ × 5′, with 1,740 plants to the acre, and opened from an adjoining estate.

NURSERY.

Nursery for 100 acres succirubra planted 5 × 5, opened January 1879.

1st Year, 1879.

3 lbs. Indian seed at Rs. 5 per lb.	...Rs. 15
Opening and cost for one year ...	... 485
	Rs...500

Plants costing Rs. 5 per acre.

2nd Year, 1880.

1 lb. Indian seed at Rs. 5 per lb....	... Rs. 5
Upkeep of nursery	... 145
	Rs...150

Plants for supplying costing Rs. 1·50 per acre.

3rd Year, 1881.

lb. seed and upkeep as before ...	...Rs. 150

Plants for supplying at Rs. 1·50 per acre.

To open 100 acres of cinchona succirubra and plant during N. E. Monsoon, December 1879 to March 1880.

Planted 5 ft. × 5 ft. with 1,740 plants per acre.

Cost of 100 acres land at Rs.	100 per acre	Rs. 10,000
Nursery	„ 5 „	500
Superintendence ...	„ 15 „	1,500
Survey fees ...	„ 2·50 „	250
Felling and clearing	„ 20 „	2,000
Roads, 4 miles at Rs. 110 per mile	...	440
Draining	7·50 per acre	750
Lining, cutting pegs, &c. ...	4 „	400
Holing and filling in ...	10 „	1,000
Planting, supplying, shading...	12·50 „	1,250
Tools	...	200
Lines (1 set, 6 rooms 12′ × 12′ at Rs. 80)		480
Contingencies (Medical Assessment, &c.)		250
Weeding 9 months at 75 cents.	...	675
		Rs...19,695

Cost of opening per acre Rs. 96·95.

100 acres cinchona succirubra are now planted, and the 1st year's expenditure will commence from April 1st 1880. From April 1st, 1880, to March 31st, 1881.

1880-81.—1ST YEAR.

Superintendence	Rs. 1,000
Nursery at Rs. 1·50 per acre	150
Supplying and shading 25 percent, at say Rs. 2·50	250
Weeding at 62 cents per acre	744
Suckering, picking caterpillars, &c. ...	100
Upkeep and improvement of roads and drains	250
Contingencies	206
	Rs... 2,700

or Rs. 27 per acre.

Season April 1881 to March 1882, or plants 2 *years old*

1881-82.—2ND YEAR.

Expenditure as before	Rs. 2,700
Staking 25 acres at Rs. 10 per acre ...	250
	Rs... 2,950

or Rs. 29·50 per acre.

Season April 1882 to March 1883, or plants 3 *years old.*

1882-83.—3RD YEAR.

Expenditure as before	Rs. 2,950

Season April 1883 to March 1884, or plants 4 *years old.*

1883-84.—4TH YEAR.

Expenditure as before	Rs. 2,950

100 acres cinchona succirubra April 1884 to March 1885, or plants 5 *years old.*

1884-85.—5TH YEAR.

Superintendence	Rs. 1,500
Weeding at 62 cents	744
Upkeep roads and drains	250
Buildings, repairs and additions to Lines..	500
Contingencies	186
Coppicing or uprooting diseased trees (as circumstances direct) say 25 per cent, at 1 lb. dry bark per tree, say 43,500 lbs. bark costing 12 cts. per lb. (including 435 waterproof bags at 1·50 each, packing and transport charges to Colombo) ...	5,220
	Rs... 8,400

April 1885 to March 1886, or plants 6 *years old.*

1885-86.—6TH YEAR.

Expenditure &c., as above	Rs. 3,180
Coppicing or uprooting diseased trees, say 25 per cent at 1½ lbs. dry bark per tree, say 65,250 lbs. costing 12 cts. per lb. as before	7,830
	Rs... 11,010

100 acres succirubra, of which half the trees have been taken out, April 1886, six months expenditure 1886, trees *6½ years old.*	
Superintendence	Rs. 1,000
Weeding	372
Coppicing balance of trees (at this age few should be diseased at the roots) at 2 lbs. dry bark per tree, giving 87,000 lbs. bark at 12 cts. per lb. as before	10,440
Contingencies	188
	Rs... 12,000

Summary.

		Cost of land, with opening and expenditure for 6½ yrs, or from commencement of nursery 7½ yrs.	Value of produce from 100 acres of succirubra so opened.
To March, 1880	To opening 100 acres with cost of land ...	Rs. 19,695	
1880-81	To expenditure ...	,, 2,700	
1881-82	,, ,, ...	,, 2,950	
1882-83	,, ,, ...	,, 2,950	
1883-84	,, ,, ...	,, 2,950	
1884-85	,, ,, ...	,, 8,400	
	By sale of 43,500 lbs. dry bark at 1*s.* 6*d.* per lb. with 10% added for exchange ...		35,887
	Home charges on above at 20 per cent ...	,, 7,177	
1885-86	To expenditure ...	,, 11,010	
	By sale of 65,250 lbs. dry bark as above		53,830
	Home charges ...	,, 10,766	
	Carried forward	68,598	89,717

	Brought forward...	Rs. 68,598	89,717
1886	To 6 months' expenditure	,, 12,000	
	By sale of 87,000 lbs. bark at 2*s.* per lb., with exchange		95,700
	Home charges ...	,, 19,140	
	To purchase of land and expenditure	,, 99,738	
	Profit	,, 85,679	
		Rs. 185,417	Rs. 185,417

or, Rs. 856 per acre, with the land free and planted with seedlings, and coppice shoots.

As before, I will give an estimate of 10 acres succirubra mossed and renewed in the most suitable way. 10 acres succirubra opened as before in 1879-80.

Expenditure at the same ratio as before, viz-, Rs. 196·95 per acre	Rs. 1,969

1880-81.—1ST. YEAR.

Expenditure at Rs. 27 per acre	,, 270

1881-82.—2ND YEAR.

Expenditure as above (no staking) ...	,, 270

1882-83.—3RD YEAR.

Expenditure as before	,, 270

1883-84.—4TH YEAR.

Expenditure as before	270

1884-85.—5TH YEAR.

Superintendence, weeding, &c.	,, 318
Stripping and mossing 17,400 trees, taking 4 oz. dry stem bark per tree, or 4,350 lbs. at 12 cts. per lb...	,, 522
Packing and transport at 4 cts.	,, 174
	Rs. 1,014

1885-86.—6TH YEAR.

Expenditure, &c., as before, stripping off the covered bark left previously ...	,, 1,014

1886-87.—7TH YEAR.

Taking the renewed bark formed over the portions of stem denuded in 1884-85, say 4,350 lbs. renewed bark, with expenditure as before	Rs. 1,014

1887.

The trees have now say ½ lb. renewed stem bark, and from April 1887 are coppiced. Six months' expenditure 1887 —*trees 7½ years old.*

Superintendence	,, 100
Weeding	,, 37
Coppicing 17,400 trees with ½ lb renewed and 1 lb natural bark per tree, say 26,100 lbs. at 12 cts. per lb. including all charges	,, 3,132
Contingencies	,, 21
	Rs. 3,290

To March,		All expenses for 7½ yrs., or from commencement of nursery 8½ yrs.	Value of produce from 10 acres succirubra.
1880	To expenditure ...	Rs. 1,969	
1880-81	,, ,, ...	,, 270	
1881-82	,, ,, ...	,, 270	
1882-83	,, ,, ...	,, 270	
1883-84	,, ,, ...	,, 270	
1884-85	,, ,, ...	,, 1,014	
	By sale of 4,350 lbs. natural bark at 1/6 per lb. and exchange ...		3,588
	To home charges on above	,, 717	
1885-86	To expenditure ...	,, 1,014	
	By sale of bark as before		3,588
	To home charges as before	,, 717	
1886-87	To expenditure ...	,, 1,014	
	By sale of 4,350 lbs. renewed bark at 3/- per lb. and exchange ...		7,177
	To home charges ...	,, 1,435	
1887	To expenditure ...	,, 3,290	
	Carried forward	,, 12,250	14,353

	Rs.	Rs.
Brought forward...	Rs. 12,250	14,353
By sale of 8,700 lbs. renewed bark at 3/- per lb. and exchange ...		14,355
By sale of 17,400 lbs. natural bark at 1/6 per lb. and exchange ...		14,355
To home charges on above	,, 5,742	
To cost of land and all expenses ..	,, 17,992	
By profit	,, 25,071	
	Rs. 43,063	Rs. 43,063

I will now tabulate the results of the preceeding estimates rejecting fractions, and shew the annual expenses and returns per acre in each case.

	Officinalis.				*Succirubra.*			
	UPROOTING.		MOSSING AND RENEWING.		COPPICING.		MOSSING AND RENEWING	
Date.	Expenses per acre.	Returns per acre.	Expenses per acre.	Returns per acre.	Expenses per acre.	Returns per acre.	Expenses per acre.	Returns per acre
To March, 1880. ...	279	...	279	..	196	...	196	
1880-81 ...	31	...	31	...	27	...	27	
1881-82 ...	36	...	31	...	29	...	27	
1882-83 ...	36	..	31	...	29	...	27	
1883-84 ...	78	...	84	...	29	...	27	
		544 ...		360				
	108	...	72					
1884-85 ...	78	...	110	..	84	...	101	
		544 ...		541 ...		358 ...		358
	108	...	108	...	71	...	71	
1885-86 ...	138	...	84	...	110	...	101	
		1,435 ...		721 ...		538 ...		358
	287	...	144	...	107	...	71	
1886-87 ..		...	199	...	120	...	101	
		...		2,165 ...		957 ...		717
		...		1,082 ...	191	...	143	
		...	649					
1887 ...		...		...		...	903	2,871
	1,179		1,822		993		1,795	
Profit per acre	1,344		3,047		860		2,509	
	2,523	2,523 ...	4,869	4,869 ...	1,853	1,853 ...	4,304	4,304

REMARKS ON PRECEEDING ESTIMATES.

The substitution of S. W. Monsoon for N. E., and the consequent change in the periods, is of course necessary for certain districts.

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"*Nursery.*" One pound of officinalis seed should, making every and ample allowance, give 70,000 healthy plants. It will frequently give considerably more. 8 ℔s. should therefore give over half-a-million plants, and this number will allow a very safe margin for failures in the clearing.

"*Cost of land*" is a nominal item. It has been put at Rs. 150 per acre. but as good officinalis forest land is not easily purchased, this is not too high.

"*Field works*" are put down at a fair cost, with ample margin.

"*Roads*" are steep and narrow, say 3 to 4 feet wide.

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"*Draining.*" The estimate for this allows for small drains, about half a chain apart, and is applicable to a clearing of good porous soil. If the soil is at all tenacious, a much more liberal allowance will have to be made; say Rs. 18 per acre, for narrow and deep drains, at a gradient of 1 in 8.

"*Lining*" has been allowed for, as there are many advantages attached to it. which have been enumerated before.

"*Holing.*" Allowance has been made for small holes, of which a cooly can cut 100 or more.

It must be borne in mind that these clearings are supposed to be opened in connection with a neighbouring estate, and therefore the allowance for superintendence, tools, and contingencies, is comparatively low, whilst no bungalow is required.

"*Lines*" are permanent buildings, which, with the allowance of Rs. 500 in the 4th and 5th years, can be converted into drying houses. The 6 rooms would not be sufficient to accomodate the coolies opening the clearing, and are only for the use of those in permanent employment on it.

An allowance of 25 per cent for failures in the 1st and 2nd years is liberal.

No allowance has been made for "*lopping*" in any of the estimates, though it is necessary in the 2nd and 4th years. and before stripping; it is considered that the cost of the work will be covered by the value of the bark obtained. Practically, there would be a profit over and above the cost.

In the 4th and 5th years, allowance is made for the death of 50 per cent of the clearing from natural causes, failing this it would be necessary to thin out almost this proportion so as to allow room for the remaining trees. Page 172

I have given 6 oz. bark as the average yield per tree at these ages, uprooted; this leaves a large margin, as ¾ lb. and more is usually obtained.

We have now uprooted the whole of our clearing. I have allowed only ½ ℔. dry bark per tree, when 5½ years old, this is very low, as one and a half pounds would probably be got. The price put, 3/- per ℔. as an average, is very low when we consider that the root bark is included, and what a high value it has.

These low averages should make ample allowance for vacancies (we are basing our calculations on 3,500 trees to the acre, an impossibility), and perhaps for damp hollows where trees would not grow.

The cost of harvesting and transporting the bark, 14 cts. per pound, will be found fairly accurate, though circumstances alter the rate considerably. 20 per cent is the usual allowance for London charges, freight, &c., as has been shewn before.

The profit of Rs. 1,343 per acre, includes the cost of land Rs. 150, and the proprietor finds himself in this position: He has purchase money and expenditure returned to him, with profit as above; he has 100 acres of cinchona land planted up by self-sown seedlings; a quarter of this acreage being two and a half years old, and ready to cut during the middle of the ensuing year, one-fourth the year after, and one-half the third year; shewing a profit at the end of nine and a half years greater than that shewn at the end of the first five years, by the saving of original purchase of land and opening expenses, Rs. 27,945, besides other little savings in upkeep and first building, always provided that the land is found capable of producing a second crop. Page 173

In the 2nd estimate I have allowed for expenditure as before, less staking. In the previous estimate allowance is made for the necessity of staking 25 per cent of the clearing, which would include a few wind blown ridges, in the case of the 10 selected acres, this allowance is obviously unnecessary. Page 174

In the 4th year 1 oz., in the 5th 1½ oz. per tree, are allowances which leave a large margin for failures; whilst the estimate of 6 oz. per tree in the 7th year, including root bark, a less amount than that obtained from the trees in the previous estimate during the 6th year, will allow for the failure of the process in some instances.

Page 175 The profit per acre appears very high, but the proportion between the two estimates is a fair one, and is in accordance with what data we have on the subject. It must be borne in mind that the estimate refers solely to the cultivation of a few acres of exceptional excellence, the large amount of labour, and skilful supervision, necessary for success, making the performance of the work on a large scale of doubtful advisability.

Page 176 "*Nursery.*" From 1 lb. succirubra seed, 100,000 plants is a fair calculation, though in many cases a far larger number than this is obtained. 3 lbs. of seed therefore allows ample margin.

"*Cost of land*" is put at Rs. 100 per acre, the suitability of most coffee plantations for the cultivation of this species lessening the demand greatly.

"*Field works*" are the same as in the previous estimates, except where a reduction is made for the smaller number of plants per acre.

Page 177 Allowance is made for the first cutting in the 5th year, of 25 per cent diseased trees, yielding 1 lb. dry bark. This will include the root bark of such trees as are diseased below the collar. The cost of barking, drying, and packing in waterproof bags, amounts to about 8 cts. per lb., to this has been added 4 cts. for transport.

Page 178 In the 6th year, 1½ lbs. bark per tree is a low estimate.

In the 7th year, the remaining trees are coppiced, yielding 2 lbs. dry bark.

The low estimates of yield, with a valuation of 1*s.* 6*d.* per lb. in the 5th and 6th years, and 2*s.* in the 7th year, will make ample allowance for failures as before. The trees all being cut, at a profit of Rs. 856 per acre, the proprietor is in the position mentioned previously. This profit is not nearly as large as what has been obtained in many instances from small acreages, but is, it is believed, in fair proportion to the preceeding estimates, and as much as can safely be counted on from a large clearing.

Page 179 In the 4th estimate, 4 ozs. dry stem bark in the 5th, 4 ozs. in the 6th, and 4 ozs. renewed in the 7th year, are by no means excessive estimates, and leave a good margin for failures. In the 8th year, 1 lb. natural, and ½ lb. renewed bark, per tree. allows fully for a large proportion of failures.

The cost of the process, 12 cts. per lb., exclusive of transport, is what has been found a fair estimate.

In this case, all natural bark is estimated at 1*s.* 6*d.* per lb. only, even in the 8th year, as in the latter case the stem

bark is not included. 3*s*. per lb. for renewed red is a very low estimate indeed.

As before, ample allowance has been made for failures of all kinds.

This table shews the comparative values of the two species, and the two methods of cultivation in each case. The advantage of ordinary officinalis cultivation over succirubra is most marked, and is what has been insisted upon previously. When we come to the more elaborate method of cultivation, the increased value is much less in the former than in the latter case. When we consider the greater ease with which the robust species is barked, and the comparative certainty of the process of renewal if carefully performed, I do not think too much stress can be laid upon the desirability of following this method in all cases where small acreages of particular excellence can be selected, and where materials for the performance of the work are at hand. The largely increased returns in the case of officinalis, make it advisable to pursue the method with this species also, under suitable conditions. Page 181

Finally, though each cultivation may be found more or less financially successful than has been shewn to be the case, in fairly favourable circumstances, I think the figures shew with sufficient accuracy their proportionate values as investments for capital.

So much land of more than doubtful suitability has been planted with cinchona in Ceylon, that the preceeding estimates are probably rather above the average results that will be obtained. Even where discrimination has been exercised in the primary selection of the land, it is a common practice to fell and plant the whole in large blocks, taking suitable and unsuitable portions. As has been shewn before, cinchona cultivation is essentially a pursuit in which the greatest care and judgment must be exercised to assure success. To take, therefore, a number of average results under unfavourable as well as favourable circumstances, and to base estimates on these data, would obviously be futile. I have assumed therefore that judgment has been exercised in the selection of the land, and that only such portions as may reasonably be expected to grow cinchona have been felled and planted ; I have, therefore, by taking a low yield per tree in each instance, and by striking off a portion of the plantation each year, made allowance for the proportion of failures, which are to be expected even in the most favourable circumstances.

No notice has been taken of the cultivation of calisaya, or other species and varieties, as we have no data to go upon.

As to the comparative values of natural and renewed bark, the figures given in the chapter on harvesting shew that the renewed is not quite double the value of the natural, though it is nearly so; but, considering that the latter includes bark from all parts of the tree, whilst the former is all from the stem exclusively, the proportion indicated should be found approximately correct.

APPENDIX.

Extract from "Ferguson's Ceylon Directory, 1880-81."

"There can be no doubt of the analytical and commercial value of cinchonas grown in Ceylon, although the highly-coloured estimates sometimes framed are out of the question. We have received from time to time abundant evidence of the liberal growth of bark on Succirubra and Officinalis trees, and of the high percentage of alkaloids, more especially of crystallized sulphate of quinine, yielded on analysis in some cases. On the first consignment of Ceylon Loolcondra) officinalis bark grown by Messrs. Keir, Dundas & Co. in Hewaheta, finding its way to the London Market in April 1868, it was reported by Mr. Howard the Quinologist :—"There must be something in the soil or climate of Ceylon peculiarly adapted to the perfect growth of this plant," and a higher price was obtained than for Ootacamund bark of the same kind.

We have been favoured by Mr. C. E. H. Symons with the following table of analyses conducted by him of cinchona bark of different kinds and grown in different districts of Ceylon. Unfortunately Mr. Symons has not received from his various constituents information in each case as to the age of the trees, necessarily a most important factor. In the case of the Lemagastenne calisayas, however, we know from the proprietor that his trees were 9 years old, and we suppose the average age of the succirubra and officinalis bark analysed will be about 5 years. Apart from age, however, the analyses are full of interest as indicating the effect of different modes of cultivation and treatment in the same district; in Lindula for instance:—

LEMAGASTENNE

Calisaya grown at 2,500 feet elevation.

No. 1		Sulphate	Quinine	2·534
2	Hybrid	do	do	4·439
3	Calisaya	do	do	1·521
4	do	do	do	2·184
9	do	do	do	2·320
11	do	do	do	1·846
12	do	do	do	1·092
19	do	do	do	0·825
24	do	do	do	1·813
40	do	do	do	3·080
45	do	do	do	1·586
67	do	do	do	2·426
77	do	do	do	4·732

DELTOTA 3,500 feet above sea-level.

Mossed bark Succ. = Sulph. Q 3·370

RAMBODA, (4,500 ft.)

Mixed parcel "twig" "root" "stem" and chips. Off. Sulph. Q. 2·586

KELEBOKKA (say 4,300 feet).

Officinalis 3·220

DIMBULA (say 4,000 ft.)

Stem Hybrid Sulphate Quinine: (say from 4,500 feet elevation) 3·243

Shavings of Stem Succ.=Sulph. Q. 3·130

RANGALA (say 4,000 feet.)

Average of whole tree Succirubra=Sulphate Quinine 2·40

MATALE WEST (3,000 feet).

Stem quill Succ.=Sulph. Quinine 2·227

LINDULA (4,500 ft)

Grown in jungle soil Succ.=Sulp.Q.			3·233
,, patna	do	do	2·413
,, jungle Hybrid Succ		do	1·963
,, do Renewed Succ.		do	4·106
,, do Calisaya			5·493
,, patana ,,			4·586

NUWARA ELIYA (6,200 ft,)

2½ year old Off.=Sulph Quinine 1·926

GAMPOLA (under 2,000 feet).

Stem Quill Succirubra 1·520

In the case of Lemagastenne, it will be observed that a hybrid proved to be nearly as rich as the best of the calisayas: all Mr. Roberts' plants of the latter were pronounced by Mr. Moens to be Hasskarliana, Josephiana, &c., inferior types to the Ledgeriana, but Mr. Howard who analysed some of the

bark expressed himself much pleased with it, and it is evident from this experience that the ordinary calisayas are going to do much better in our Ceylon soil and climate than in Java, while the yield of bark at 2,500 feet promises to be greater than from succirubra. Many planters think that as a rule the *common* varieties of Calisayas improve with age to a greater extent than Officinalis and Succirubra, but where the limit is we cannot say."

"From published analyses we take as a typical instance one made by Mr. A. C. Dixon, F.C.S., of hybrid cinchona bark from trees on Bridewell estate, Bogawantalawa (over 4,500 feet we suppose) about 5½ years old. The result was as follows from four average trees in each case:—

A	per cent.	B	per cent.
Crystallized Sulphate of Quinine	3·51	Crystallized Sulphate of Quinine	3·94
Cinchonidine Sulphate ...	2·41	Cinchonidine Sulphate ...	2·86
Cinchonine Alkaloid ...	0·92	Cinchonine Alkaloid ...	1·02
	Total...6·84		Total...7·82"

"The best analyses I have done of stem bark are, for Succirubra:—

Crystallized Sulphate Quinine	2·85
,, ,, Quinidine	·34
,, ,, Cinchonidine	3·81
Cinchonine alkaloid...	·85

Of hybrids of Officinalis type crystallized Quinine Sulphate up to 3·47%. Of Calisaya Ledgeriana up to 4·79 Sulphate Quinine."

Another careful analysis of bark from Mr. Heelis, of Langdale, Lindula, may be recorded. He writes:—"I should say there was about 2lb. stem and ½lb. twigs in all on the tree, 8 years old, and under the average of others in boundaries of same age; *Analysis of Bark* forwarded by Messrs. Robert Brooks & Co. of London—8 years old officinalis, grown in open, natural bark. Elevation 4,600 feet. From a tree at Langdale bungalow—1 lb (7,000 grains) yielded Commercial: Crystallized sulphate quinine, 356¼ grains; Cinchonidine, 79¾ grains; Alkaloid cinchonine, Trace. We estimate the value according to above at about 10s per lb."

Yet another of young bark on Mr. Northmore's Pussellawa property may be given; analysis by Mr. C. E. H. Symons. He writes thus:—"The bark "contains total alkaloids 3·870 per cent of which crystallized sulphate of "quinine=1·533 per cent which would give a gross value in London market "of 2s 6d sterling per lb. I may add that the proportions of cinchonidine "and quinidine are very good, the percentage of cinchonine being small.' Mr. Northmore writes:—"The interest and value of the analysis arise from' the fact that the trees from which the bark was cut (stem bark) were only 21 months old, having been planted in June 1878. They are grown in old and luxuriant coffee which I planted in 1856, and the particular field is at an elevation of nearly 4,000 feet. The trees, at the time of cutting, had attained a height of between five and six feet."

A more complete, though less varied, table of analyses than the one given before, has come to us from Mr. Cochran, Analytical Chemist, the samples being all from one estate, and the information afforded is all that can be required to enable the planter of cinchona among coffee in old districts especially, to learn valuable lessons which Mr. Cochran points out:—

Table of Analyses of ten Samples of Cinchona stem bark grown in Matale at an elevation of about 3,500 feet:—

No. of sample...	1	2	3	4	5	6	7	8	9	10
Species of Cinchona ...	Suc.	Hybrid.	Suc.	Hybrid.	Hybrid. renewed.	Suc.	Suc.	Suc.	Suc.	Suc.
Age of tree in Years	7	6	7	7	7	7	3½	3½	3½	7(?)
Moisture... ...	11·05	11·25	10·90	11·8	12·6	14·15	15·05	13·95	14·65	8·10
Crystallized Quinine Sulphate:	·61	2·45	1·32	3·31	3·59	1·27	1·16	·77	·74	1·14
Equal to Quinine	·45	1·82	·98	2·46	2·67	·94	·86	·57	·55	·85
Cinchonidine & uncrystallized Quinine	4·99	3·17	4·93	6·14	5·66	4·92	4·59	4·43	4·35	4·47
Cinchonine with traces of Quinidine	·85	·68	2·10	1·30	·12	2·12	1·42	Trace	·52	1·19
Total Alkaloids	6·29	5·67	8·01	9·90	8·45	7·98	6·87	5·00	5·42	6·51
Condition of Stem as to shade	severely lopped	severely lopped	shaded by its branches	shaded by its branches	shaded by its branches	shaded by its branches	slightly lopped 1st year	slightly lopped 1st year	severely lopped	severely lopped
Other conditions of growth	growing among coffee	growing among old coffee	growing among old coffee	growing among old coffee	growing among old coffee	growing among old coffee	new clearing luxuriant	new clearing dying out	new clearing windblown	growing amnog old coffee

The sender of the above samples of bark to Mr. Cochran remarked, 2nd October 1880:—"I send you two samples of bark No. 1 and 2. I am anxious to have analysis of same to see whether cinchona growing amongst coffee now 40 years old is likely to be fairly profitable. The growth is fairly good and would give, I think, an average of 3 lbs of dry bark per tree from stem and branches. The trees from which these samples were taken had been severely lopped."—17th November 1880:—"I have decided to follow up a few of the vexed questions connected with the increase of the alkaloids or otherwise. I send by to-day's tappal the following:—No. 3 sample from the stem of succirubra tree seven years old quite protected from the rays of the sun by its own branches, growing at the same elevation and in the same sort of soil and planted at the same time as No. 1 already analysed, and entirely dried in the sun, the only difference in the conditions of growth in the two samples being the severe lopping up of No. 1.

"No. 4 is from a hybrid tree growing under almost identical conditions with No. 3, that is age, elevation, soil, shade, and dried in the sun.

"No. 5 is from the stem of the same hybrid tree where the bark had been sensibly disturbed, resulting in it all being nearly renewed without any shade or covering but that which was offered by the growth of the branches."

22nd November 1880:—"I forward per to-day's tappal other four samples of bark as follows:—

"No. 5 all conditions similar to No. 3 and from same tree except that it has been entirely dried in the shade under the store roofing.

"No. 7 from the stems of several trees of a 3½ year old clearing, where the growth has been vigorous and luxuriant, and where the trees have not been lopped up except slightly the first year, the stems have been consequently well protected from the direct rays of the sun.

"No. 8 is from trees planted at same time as the last and in same clearing, that were dying out, owing evidently to their having touched a stratum of wet soil.

"No. 9 is also from trees grown on a severely wind-blown ridge of same clearing and planted at same time as the last two, but that were severely lopped up before each south-west monsoon, the growth of which has been consequently very much restricted and not equal to say more than a third of No. 7 and 8."

18th December:—"I forward sample No. 10 from the finest Succirubra tree on the estate that was severely lopped up along with the others, and has now been subjected to the mossing process. This will be confirmatory or otherwise of No. 1 and be a means of comparison with the mossed bark afterwards."

The above analytical results lead to the following conclusions:—That quinine and the other alkaloids are increased by having the stems of Cinchona trees shaded from the direct rays of the sun. That the bark of hybrids such as that analysed may be renewed without any covering with an increase of quinine and diminution of cinchonine. That it is immaterial whether the harvested bark be dried in the sun or in the shade. That vigorous growth is preferable to retarded growth in young trees.

It may be worth remarking that in the case of sample No. 8 from dying trees the crude alkaloids were obtained almost free from resinous and coloring matters; and the crude alkaloids of No. 9 were the next purest.

1st March 1881. M. COCHRAN.'

CINCHONA PLANTED.

	1867	1869	1870	1872	1873	1874	1875	1876	1877	1878	1879	1880
Acres	50	100	200	500	1,500	2,000	3,000	4,200	5,578	10,000	20,000	33,568

We count 3,000 trees to the acre as already explained, but even if our estimate of 50 millions growing plants, likely to come to maturity, be considered too high at this date (March 1881), there is the certainty that this estimate will be more than made up before the third quarter of 1881.

Of the export trade in bark, the following is from the Official Customs accounts:—

Exports of Cinchona Bark from Ceylon.

1869 ...	28 oz.		= value	R50
1871 ...		80 packages	= ,,	R313
1872 ...	11,547 lb.	and 694 packages	= ,,	R64,102
1873 ...	44,836 ,,		= ,,	32,667
1874 ...	40,354 ,,		= ,,	25,277
1875 ...	19,152 ,,		= ,,	17,963
1876 ...	14,932 ,,	and 1 package	= ,,	14,720
1877 ...	72,127 ,,	and 1 do.		88,738
1878 ...	186,797 ,,			171,292
1879 ..	507,368 ,,			519,086
1880 ...	1,161,989 ,,	(Say)		R1,200,000

Commercial Seasons—(Chamber of Commerce Return): lb.

1st Oct. 1874 to 30th Sep. 1875 = 18,731 lb	1st Oct 1878 to 30th Sep 1879 = 373,511
do 1875 do 1876 = 16,842 ,,	do 1879 to do 1880 = 1,208,518
do 1876 to 30th Sep. 1877 = 56,589 ,,	do 1880 to 3rd Mar. 1881 = 229,612
do 1877 to do 1878 = 173,497 ,,	

In consequence of short coffee crops and financial depression, Ceylon planters have had to cut and bark a good many trees, prematurely we fear, during 1879-80 and possibly the same will hold good for 1881. It is scarcely possible we can keep up the export to a million lb., during 1882 and 1883,

indeed in the present year, we look for a falling-off, as compared with last, but from 1884 onwards a steady increase in the export trade may be expected, and we suppose in about five years Ceylon should be able to send three or five million lb. of bark per annum into the home market and to keep up this rate of supply steadily, provided falling prices or local utilisation of the bark for the extraction of the alkaloids do not interfere too much.

ESTIMATED PRODUCTION OF CINCHONA BARK OF ALL KINDS.

	Area Cultivated. Acres.	*No of Trees planted of all kinds.*	*Average Estimated, Produce in dry Bark per annum.*
India :			
Sikhim (Govt. plantations)	2,400	5,000,000	400,000 lb.
Darjiling (Private ,,)	1,800	1,500,000	150,000 lb.
Nilgiris (Govt. & private)	2,200	2,000,000	300,000 lb.
Wynaad, Mysore & rest of India	3,600	6,000,000	100,000 lb.
Ceylon	33,500	50,000,000	1,000,000 lb.
Java	7,500	9,000,000	450,000 lb.
Jamaica	800	600,000	50,000 lb.
Mexico	50	20,000	———
South America :			
Colombia & New Granada	(Large area covered with indigenous trees)		12,400,000 lb.
Peru and Bolivia ...			3,500,000 lb.
Ecuador			2,500,000 lb.
Rest of South & Central America			1,000,000 lb.
			Total...21,850,000 lb.
Total (apart from S. America)	52,850 acres;	74 millions of trees;	

IMPORTS AND CONSUMPTION OF CINCHONA BARK.

United Kingdom and British Colonies import about 9 millions lb., but consume only	3,500,000 lb.
India (manufactures from local growth apart from quinine, &c., imported)	500,000 lb.
Europe, Continent of, through Holland and France ($5\frac{1}{3}$ million lb.) chiefly	8,500,000 lb.
United States	6,500,000 lb.
Other Countries (Brazil, Africa, and rest of Asia)	1,000,000 lb.
Increase within next few years	1,850,000 lb.
	Total...21,850,000 lb.

It is supposed that 13 millions lb. of bark have hitherto been used up every year for quinine alone; apart from the quantity required by druggists for bark preparations; by German brewers as a substitute for hops; and of red bark as a dentifrice in some countries. America imported 6,720,000 lb. of bark in 1879, her average importation previously being 4,480,000. France imported 5,331,000 lb. bark in 1880 and consumed 3,071,040 lb.

Messrs. Gehn & Co , of Dresden estimated the consumption of quinine in 1879 at 220,000 lbs. worth £1,920,000. On the other hand the *Journal de Pharmacie de Constantinople* says that a statistical calculation of the amount of quinine used in the world shows that 100,000 kilogrammes (more than 98 tons avoirdupois, or 220,000 lb as above) are consumed; the value of this being 56,000,000 francs (£2,240,000). If to this be added the cost of other salts of quinine—the hydrochlorate, hydrobromate, etc.,—the result will be a total sum of £2,248,000 spent annually in quinine alone. Corresponding with this a New York Journalist says :—"When a man takes his quinine pill, how

little does he realize that $11,600,000 are expended annually throughout the universe for this bitter blessing." As regards the future of consumption besides new uses for the bark, there is an immense scope for the extension of the demand for quinine and quinetum when once the febrifuge is made generally available at one-half or perhaps one-fourth the present price. Mr. Clements Markham notices one possible field of almost unlimited consumption in China, and this market ought to be kept steadily in view more particularly since the opium scandal might be thereby removed. Mr. Markham says :—

"It has been suggested by a writer in the *Pall Mall Gazette* of September 18, 1880, that China will hereafter be among the largest and most constant customers for cheap febrifuge alkaloids from British India. From the vast tracts of country in China where rice is cultivated, fever is never absent. Opium is now employed as the medicine easiest to be had and the cheapest. If cinchona alkaloids could come into competition with opium, and obtain the preference by their lower price, the immense superiority of cinchona over opium as a febrifuge would produce a revolution in the Chinese consumption of the two drugs. By this process a solution would be found for the dangers and uncertainties of the large opium revenue of India, and for the perplexing moral questions connected with it."

MANUFACTURE AND CONSUMPTION OF QUININE.

The total quantity of prepared quinine has been estimated by the United States Consul at Milan at from 230,000 to 260,000 lb. per annum, accounted for in this way :—

Manufactured by	lb.	Consumption. (*Estimated by Compilers.*)	lb.
United States	63,000	United States...	88,000
Germany	56,250	Germany, Holland & Belgium	30,000
Italy	45,000	Italy	22,500
France	40,000	France	20,000
England	27,000	Russia, Austria, Turkey & Greece	40,000
India	12,500	India	17,500
		(Other countries, Japan, Brazil, Africa, and Australia, &c.)	25,000
	243,750		243,000

PRICES OF CINCHONA BARK :

(*In the London Market, duty free, per price current*, 11th *February* 1881.)

South American :—	fine...	6s to 8s per lb.
	good	4s to 5s
	fair	2s to 3s
	ordinary	1s to 1s 6d
	low	3d to 9d
Ceylon :—Crown...	good and fine quill	6s to 7s
	branch	3s to 5s
	chips	2s to 4s 6d
Red...	fine quill	3s to 3s 6d
	fair to good	1s 6d to 2s 6d
	young branch	9d to 1s
	chips	1s to 2s
	twigs	4d to 6d
Nilgiris :—Red	natural	1s 6d to 3s
	mossed	3s to 4s
	renewed	4s 6d to 5s
Crown—	natural	4s to 5s 6d
	mossed	5s to 6s
	renewed	7s to 8s
Darjeeling, Red	fine quill	3s 6d to 4s
	good	2s to 2s 6d
	fair branch	1s to 1s 6d
	weak do	9d to 1s

Chemical Analyses.

"The chemical analyses were chiefly intended to prove the yield of quinine from blossoming and seed-bearing ledgeriana trees, The analyses 1 to 34 are of such barks. The most remarkable is the yield of 13·33 p. c. of quinine in No. 3, which has certainly never before been equalled by a cinchona bark. Some more hybrids also were analysed, which all contained less alkaloid than the best of the trees from which they are derived. Although it was known of succirubra that the renewed bark, at least on the first occasion, is richer in quinine than the original, an experiment with renewed ledgeriana bark has demonstrated that such is not the case with this variety. The analyses referring to this are given in the table under 33 and 34. The difference between the original and the new-formed barks is seen from the following table:—

	No. 33.		No. 34.	
Alkaloid.	*Orig. bark*	*Renewed*	*Orig. bark.*	*Renewed.*
Quinine.	7·49	3·68	8·68	5·40
Cinchonidine	——	——	——	——
Quinidine	——	——	——	——
Cinchonine	——	0·[illegible]5	0·11	0·33
Amorphous alk.	1·41	0 61	0·85	0·67"

Extract from "Report on the Government Cinchona Enterprize in Java for the year 1879."

"As was predicted in the former annual report, the first ripening of the Ledgeriana seed in 1879 was very late—in November and December. And the quantity was small, so that the orders of private planters in Java could scarcely be executed, while to British India and Ceylon planters on this occasion no seed of this variety could be spared. The Cinchona Ledgeriana appears, more than the other kinds, to require a long dry season, in order afterwards, when the rain falls, to bring forth blossom in abundance, so that after the extremely dry year 1877 nearly every tree blossomed. After the unusually wet east monsoon of this year, there is the fear that now also again little blossom will appear,—and in that case that in 1880 also the fruit will not ripen before December. The planting of cuttings of Ledgeriana was continued steadily, but the success continues small, although attempts were made in many ways to introduce improvements into the mode of treating the cuttings. As the experiments made sometime ago—especially in 1876—to graft Ledgeriana on other varieties of cinchona were not crowned with such success as to lead to their continuance, this year another method of grafting was practised which has succeeded excellently and promises well. The Ledgeriana grafts are now grafted on succirubra stems of about a year old, or on good rooted cuttings of this variety, in the manner employed in Europe for the grafting of rhododendrons, &c. The whole operation takes place in the forcing-houses, where plants remain until they have made a good growth A portion of these grafts, about 2,000, have already been planted out, and they are now at the commencement growing very vigorously. The question is,—and it can only be settled by the experiment,—if the graft can continue to grow on the succirubra stem and then share in the advantage of the quick strong growth of the red cinchona, or if this cannot take place in the long run. In the latter case an experiment will be made

of placing the grafts very low down on the succirubra stems, and then planting these so deep that the graft itself will have the chance of sending out roots and growing on its own account. The great advantage expected from this artificial propagation is, besides a quicker growth of the Ledgerianas, the possibility of obtaining a number of plants from the best of the trees experimented on. The attempt to grow cuttings of these, though often made, never succeeded, while now about a thousand thriving grafts of these trees very luxuriantly developed are ready to be planted. Among these are *inter alia* about a hundred slips of the tree No. 67 which yielded 13·3 p. c. quinine. The layering of Ladgerianas, formerly tried now and then with good results, has been carried out this year on a larger scale, and this method of propagation also succeeds excellently.

"It has been found that cinchonas grow much less readily on ground which has already been planted with cinchona than upon fresh jungle land. The same is the experience with the coffee estates, and in the case of the Government coffee culture the result has been a system of cultivation whereby the old gardens are being constantly written off and allowed to revert into fields of alang-alang, glagah, and lantana, and new forest is felled for the purpose of opening new gardens. Notwithstanding the great expense attendant on a first opening, the advantage to the enterprise apparently is greater—on account of better and quicker growth of the cinchona trees—if the old fields, as soon as the first planting is cropped, are regularly abandoned, new land being opened. However, it is not for a Government enterprise to set such an example, and it will therefore be endeavoured by an increased and rational culture of the soil, and by bestowing more pains upon the plants, to bring those lands which from time to time become of a less satisfactory condition into a flourishing state. Since it is thought more advantageous to cover these lands, planted for the second time, as quickly as possible with a close grove of trees, closer planting is adopted on these places,—at scarcely four feet apart in fact. After three to four years the gardens will need thinning out probably, and will even then yield, in the case of Ledgeriana, bark of some value. As, on account of the want of labour, there was not enough land at Kendeng Patoeha prepared for the officinalis plants, which were too big to remain longer in the nurseries, it was necessary to plant at only three feet apart. With this variety, which has a very slender stem and scarcely any side branches, there is every hope of a good result following on this plan. Here also in time thinning out will have to be considered. The chemical analyses of young Ledgeriana seedlings and officinalis plants of 3 to 4 years old also served for the collection of more data for the regulating, according to knowledge of ascertained facts, of the distance at which it is necessary to plant. A four-years-old Ledgiriana tree yielded on an average 0·26 kilogram of bark, so that four trees of this age are needed to give one kilogram of dry bark. The three year old officinalis trees gave per tree 0·088, the four year old 0·155 kilogram dry bark, so that 12 to 7 trees respectively would be necessary to produce 1 kilogram of bark. The trees on which these experiments were made stand at distances of 6 feet for Ledgeriana and five for officinalis, and are growing well. According to the analyses the average value of these barks was estimated at *f* 6 and *f* 4 per kilogram, according to the present market rate. Measurements were also taken in a flourishing garden at Tjibeureum of two

year old trees planted $5\frac{1}{2}$ feet. The average height was 1·45 meter, the diameter of the top 1 meter, while the circumference of the stem was 0·1 meter measured at 0·1 meter above the ground. Among 50 trees standing together, which served for the purpose of this measurement and will also serve for the continuation of these experiments, only two could be considered hybrids. The maximum given by one of these trees was a height of 1·9 meter, a diameter of the upper part of 1·4 meter, and a thickness of the stem circumference of 0·14 meter. The *Helopeltis Antonii* continued its attacks on the plants, though not to any great degree. The catching of these insects was carried on steadily. But when they appear here and there at the very highest tops of the succirubra trees where they cannot be reached they spread once more over the plants, and the extermination of these pests is most unlikely. At Rioen-Goenoeng half a bouw of Ledgeriana plants was entirely destroyed by the koe-oek, the larva of a chafer, which had chosen the finer rootlets in this plantation for its food. In the young succirubra gardens at Lembang many caterpillars of *Daphnis hypothous* CRAM. were found, which were feeding on the leaves of this variety of cinchona but otherwise did no harm to the plants. As the officinalis gardens at Tjinjiroean Tjibeureum and Rioen-Goenoeng—which were apparently opened at too low an elevation for this variety—were steadily getting worse, were continually damaged by the *Helopeltis*, and were gradually dying out entirely, it was resolved at the end of the year to write off the whole of the trees, to dig out what remains, and to use the land for other varieties.

"The experiments with the mossing system of McIvor were continued, and in 1879, 1,129 succirubra and 716 officinalis trees at Tjibitoeng and Kawah-Tjiwidei were again treated by this method. For covering indjoek was chiefly used this time in place of moss, as it had already been found that this stuff succeeded quite as well, was more easily procurable, and allowed of a more rapid completion of the trees. Of the hundred succirubra trees which were treated in this manner in 1877 for the first time at Tjinjiroean and Tjibeureum not one has yet died. In 1878 the second strip was not taken from 18 of these trees, as the first had not completely renewed. In 1879 it appeared that on 12 trees the second strip had not completely renewed. The renewed bark of the first strip, which was thus two years old, was now taken off. In those parts where the renewing had succeeded well the bark was quite loose and was 6 to 8 millimeters thick. In many places, however, it was thinner and adhered closely to the stem. Altogether 160 Amst. lb. were obtained from this experiment. These trees have thus yielded :—

In 1877 240 A. lb. original bark,
,, 1878 280 ,, mossed original bark,
,, 1879 160 ,, renewed bark.

On stripping for the third time the impression was created, that it would be better, in place of taking off the renewed bark in the third year of the experiment, in this manner, when it is two years old, to wait another year, and thus to give the tree a year's rest. According to information from British India the same result has been arrived at there. 1878 at Tjinjiroean, Tjibeureum and Tjibitoeng together 1000 trees were stripped according to

McIvor's method, which yielded 1,252 A. lb. bark. At Tjibitoeng, on the removal of the second strips of original bark, the trees were carefully examined, and it was found that of the 454 trees, which were covered half with moss and half with indjoek, in the case of 274 the first strip had renewed completely, in 1878 it was not entirely renewed, and in 2 it had entirely failed to renew. Of these trees 23 had been injured by the larvæ of coleoptera, and of these 28 had been covered with moss and 4 with indjoek. At Kendeng Patocha (Kawah Tjiwidei) in 1878, 50 officinalis trees were partially stripped. They then yielded 27 A. lb. bark. In 1879 the second strip was removed, and again 27 A. lb. bark were obtained. Seven trees had died, in ten the first strip had not renewed, and many had been injured by the larva of a chafer (*Eurytrachelus eury ephalus*, Burm) which, under the moss, bored through the stems. In 1879, 2,316 trees were again operated on, which yielded 826 A. lb. dry bark. At Nagrak the experiment was made on C. Calisaya Schuhkraft. From the first stripping in 1878 70 A. lb. and from the second in 1879 65 A. lb. original bark were obtained. At the end of a year four of the trees were dead, and on 20 the bark had not entirely renewed. The expenses of mossing were made up in various ways, and depended chiefly on the greater or less difficulty of procuring moss and indjoek. They averaged, in the case of succirubra, at the first stripping: for moss covering 15—24c. per tree, for indjoek covering 10—18c. per tree. At the second stripping 51—2c. was necessary, at the third about 11c. per tree. The indjoeking of the officinalis trees at the first stripping cost 5c, the mossing 6½c. per tree. On the whole the impression conveyed by this method of harvesting in the case of succirubra is not unfavourable, so far as the experiment has gone. The succirubras which have been three years under this treatment have as healthy an appearance as trees left intact, as in the case of those where the bark did not renew the bare patches of wood, which died on the surface, were for the most part covered by the outgrowth of the interjacent strips. That many of the officinalis trees and several succirubras will be attacked by insects, was feared from the first. By covering with indjoek the evil will apparently undergo a diminution. The renewed bark is of very good quality and of a high commercial value. There are, however, some great drawbacks connected with the method. The material for covering, where the work is done on a large scale, is difficult to procure. The stock of moss in the immediate neighbourhood of the gardens is soon exhausted, and it has then to be sought longer and at a greater distance. Indjoek is also difficult to procure in quantity, and if it has to be brought from a distance it is expensive, has to be often fetched, and thus takes away too much labor. Private persons in British India are already making use of the straw of a species of grass, the fruit of which is eaten by the natives (coraly-grass), which is apparently *cynosurus coracana*. On account of the scarcity of labour at present prevailing in the cinchona gardens, it is with difficulty that men can be spared for the stripping and covering, which moreover requires the best men. The experiments of treating other varieties besides succirubra and officinalis according to McIvor's system gave results which cannot justify their continuation, as the renewed barks were not much better than the original. Renewed officinalis barks will for the first time be analyzed in 1880. The experiments with the method first begun in 1878, of cutting the bark in chips from the

living tree, were continued in 1879. A year after the bark was cut from five experimental trees this was repeated for the second time. On the first occasion there was obtained from these trees about 0·52 kilo and on the second 0·41 kilo dry bark per tree, so that the bark had replaced itself to almost its original weight in one year's time. On these trees only half of the bark was cut from two sides of the stem, while the two other sides were left intact. Regarding the chemical investigations of these barks, which are very remarkable, information is given under sec. 8. Although the quantity was very satisfactory the quality left something to desire, and it will be advisable to give the barks somewhat longer—at least two years—rest. For this reason, the larger experiment, with 60 trees, has not been continued this year but will be deferred till 1880. For the first time this method has been tried on 110 officinalis trees, which yielded 95 A. lb. bark, on 121 succirubra trees which gave 339 A. lb. bark, and on 459 Ledgerianas from which 590 A. lb. dry bark was obtained. These barks were despatched with the crops of 1879, for the purpose of ascertaining their commercial value. The officinalis trees suffered apparently not in the least, the Ledgerianas somewhat more than formerly and the succirubra trees looked very sickly for some weeks. Probably one reason of this is that whereas the former experiment with this method was made in the dry season the bark is now cut off at the beginning of the rainy season, it being supposed that the trees bear this treatment probably better in the period of rest than when the flow of sap is in full force. The injury is not permanent, for at the end of one to two months the appearance of the trees was perfectly fresh and healthy. The cost of scraping was: for succirubra 5 cents per tree or 1·8 cent per lb. bark, for Ledgeriana 2·2 cents per tree or 1·7 cent per lb. bark. The succirubra trees were scraped to a height of 3·8 meter, the Ledgerianas to 1·8 meter above the ground. The stems were not covered with moss or indajock. The experience, that the replanting of a land where a cinchona plantation has been already cropped occasions such difficulties, makes it all the more important to find a method which permits the obtaining of a regular supply of bark without killing the trees themselves for that purpose. There was sold this year a Amsterdam on account of private parties 165 bales and 29 chests of cinchona bark, the produce of the lands Pamanoekan and Tjiasem Tjiomas, Waspada and Lerep. The barks were analysed for sale by Messrs. d'Ailly & Sons. The prices were in accordance with the qualities offered, and the yield of alkaloid satisfactory.

"As it was important, on account of the notorious proneness to hybridization of the varieties of cinchona, to obtain a more accurate knowledge of the mode of fertilization, particular attention was paid to this subject at the proper blossoming season of the cinchonas, which lasts from January to March. The cinchonas have heterostyle flowers, which are thus brought into mutual fertilization by insects. In most cases the corolla tube is pretty long, and the style often very short, so that, as a rule, only insects possessing a long proboscis can be of help in the fertilization. At the top of the inferior ovary, and thus at the foot of the style, is found a disc, which secretes honey, and the insects cannot get at the honey unless they penetrate the corolla tube with their proboscis, and in doing this bring the pollen of the mature stamens in contact with the pistil. But they also carry off portion of the pollen on

their proboscis from one flower to another, and so the fertilization takes place easily enough. Not only in the case of the insects to be mentioned afterwards, is the pollen found on all parts of the mouth, but on the drones (*Bombus rufipes*) it is met with in clusters on the metatarses of the hind legs, and easily recognized under the microscope as cinchona pollen. The chief agent in the fertilization is the drone already mentioned, *Bombus rufipes*, LEPEL., which is found in millions in the cinchona plantations, attracted by the very strong odour of the cinchona blossoms, an odour which can be perceived at some distance. These hymenopters are to be seen flying with eagerness from one cluster of blossoms to another and not omitting a single open flower : from each blossom they gather honey and increase there a stock of pollen...............Now, as these insects fly also from one plantation to the next, from one variety of cinchona to another, it is evident that frequently pollen from one variety is transferred to the other, and so often from seed hybrids are obtained : and also that in a year like 1878, when, after the preceding draught, almost all the Ledgeriana trees blossomed, the chance of hybridization is much less,—as the insects can then keep more to the one variety of cinchona, and do not need to fly from one to the other,—than is the case when in each plantation only a few trees of the same variety come into flower at the same time. Among the plants from the seed of 1878 moreover there appeared much fewer hybrids than among those raised from seed obtained in other years. Experiments were tried purposely this year with artificial fertilization, and of these the following succeeded : micrantha × Calisaya Javanica, micrantha × Calisaya Schuhkraft (Josephiana), micrantha × Officinalis, Pahudiana × Calisaya Schuhkraft, and Succirubra × Calisaya Javanica. The fruits are not yet ripe : the seeds will be kept separate in order to gain further knowledge of the product of these crossings.

"The state of the weather was not favourable for the blossoming of the Ledgerianas. On this account also little bark from blossoming trees was analyzed—only the numbers 22, 71 and 72, refer to such analyses. The analyses 1—21 are of various portions of bark from the same tree. The analysis showed that in the case of these (now twelve years old) Ledgerianas the bark over a great portion of the stem is very rich in quinine, and that only that from the upper portion of the tree and from the thinner branches is of less value. Perfectly inexplicable is the variation which was observed : that, for instance, the bark at a height of 5 meters was equally rich in quinine as at 1½ meter above the ground, while the portions lying between them contained less of that alkaloid. It was in accordance with previous experience that the root bark contained much more cinchonine than the stem bark, and it is noteworthy that quinidine, which is entirely wanting in the stem bark, was found only in this root bark. In order to have a basis of comparison for the Ledgeriana seed plants, it was ascertained what was the yield of alkaloid from the intermixed bark obtained by cutting a strip of bark from ten two year old strong shoots of coppiced original Ledgerianas. The analysis is given under No. 48. As a second basis of comparison, use can be made in the investigation of the young twig bark under No. 21. In the examination of the Ledgeriana seedlings several important results were obtained. In the first place it appeared that the young trees followed as a rule the composition of the mother trees, so that for example when the latter contained quinidine the

seedling also contained that alkaloid. In the second place, it was seen that it was possible to pick out the very worst, mostly hybrid sorts, for when this was done the analysis shewed quinine-yield corresponding with the valua'ion based on the external appearance. If of seedlings of one same parent tree four types were taken, of which 1 was considered the best and 4 the worst, the analysis generally confirmed this. And lastly it was found that in general the quinine-yield for such young trees is very satisfactory, and gives the best hope for the future. The analyses 29—43, 49—69, and 73—80 refer to these young three to four year seedlings. Those distinguished by letters (A, B, C, &c,) were examined, partly as representatives of the Ledgeriana type, partly (9—53) as types of large-leaved micrantha-like descendants, which as was supposed, appear to be of little value. Very high figures for quinine were given by No. 32, 36, 37, 38, 41, 61 and 69. Of otherwise similar descent and exterior, those trees which had developed most gave the highest figure for alkaloid-yield. As was said in sec. 4, the five test trees which a year ago were scraped now again had the renewed bark taken off. For comparison of the difference in composition between the original bark and that renewed, after scraping, in one year, they are here placed side by side :—

	No. 1. uncovered		No. 2. with moss.		No. 3. with indj.		No. 4. with moss.		No. 5. with moss.	
	Original bark.	Renewed. bark.	Original.	Renewed.	Original.	Renewed.	Original.	Renewed.	Original.	Renewed.
Quinine	7·57	5·63	7 90	8·00	8·61	5·74	6·67	5·37	6·10	5·30
Cinchonidine ...	..	...	...	...	...	...	...	...	...	...
Quinidine	..	...	...	...	...	...	...	..	...	...
Cinchonine	trace	0 38	trace	0·38	trace	0·70	0·42	0·47	0·23	0·41
Amorphous alkaloid	0·76	0·17	1·28	0·17	0 91	0·35	0·24	0·17	0·36	0·15
Total ...	8·32	6·18	9·18	8·55	9·52	6·79	7 33	6·01	6·69	5.86

"It will be seen that there is a remarkable agreement in these renewed barks. No. 2 alone shows a difference, which cannot be explained. But if this tree is left out of the reckoning there is very little difference in the results of the four remaining analyses, although the yield of the original bark varied greatly, so that it appears that in this renewing, at the beginning at least, a bark of very uniform composition is formed, as regards the alkaloid-yield. The formation of so much cinchonine in this young tissue is also peculiar—a peculiarity which is also noticed in renewed succirubra bark. No. 2 cannot owe its high quinine yield to the moss-covering, else the same influence would have operated in 4 and 5. The cutting off the bark in shavings from the living tree was, as an experiment, also tried on officinalis and succirubra trees. The analyses of these barks are given under 117 and 90 and 91. The examination of renewed succirubra bark was also continued, and no diminution was observed in the yield of quinine, which rather increases steadily. The renewed bark, No. 85, which was 26 months old, is certainly of very great value. The renewed bark of some other varieties of cinchona gave no remark-

ably good results. In the following table are placed side by side the analyses of the original, original mossed, and two-year renewed bark of the same trees :—

Composition	C. Succirubra 1.			C. Pahudiana 2.			C. Hasskarliana 1.		
	Original	Original mossed	Renewed	Original	Original mossed	Renewed	Original	Original mossed	Renewed
Quinine ...	0·67	1·06	2·75	1·12	1·56	1·15	—	—	0·41
Cinchonidine	2·36	2·90	0·81	0·57	0·26	—	—	—	0·26
Quinidine ...	—	—	0·05	—	—	—	1·17	1·70	1·37
Cinchonine...	3·73	4·72	3·37	1·10	0·40	—	1·47	1·60	0·75
Amorphous alkaloid ...	0·70	0·52	0·84	1·05	2·03	1·72	0·27	0·26	0·41
Total...	7·46	9·20	7·82	3·84	4·35	2·87	2·91	3·58	3·20

Composition	C. Hasskarliana 2.			C. Micrantha 1.			C. Micrantha 2.		
	Original	Original mossed	Renewed	Original	Original mossed	Renewed	Original	Original mossed	Renewed
Quinine ...	1·42	1·96	1·16	—	—	0·10	—	—	0·10
Cinchonidine	0·31	0·77	—	1·95	2·04	0·38	1·98	2·23	0·60
Quinidine ...	—	—	—	—	—	—	—	—	—
Cinchonine...	1·06	1·16	0·75	3·15	4·38	3·35	2·00	2·00	2·18
Amorphous alkaloid ...	0·41	0·40	0·79	1·16	0·20	0·05	0·48	0·11	0·05
Total...	3·20	4·29	2·70	6·16	6·62	3·88	4·46	4·34	2·93

Composition	C. Calisaya Schuhkraft.		
	Original	Original mossed	Renewed one year old
Quinine ...	Not analysed	0·79	1·02
Cinchonidine		—	—
Quinidine ...		1·10	1·33
Cinchonine...		1·50	1·20
Amorphous alkaloid ...		0·66	0·41
Total...		4·05	3·96

" In succirubra there is usually some quinidine formed in the renewed bark, but specially distinct is the formation of a large quantity of quinine and the diminution of a great deal of the cinchonidine, while the yield of cinchonine sometimes remains the same ; though it usually somewhat increases. In the other barks there is an evident disposition to form more quinine and less cinchonidine, but the increase is not remarkable and is not complete enough to justify the application of McIvor's method on a large scale to these sorts. The barks which were rich in quinidine—Hasskarliana 1 and Calisaya Schuhkraft—produced this alkaloid also in the renewing of the bark. The analyses of C. officinalis, C. lancifolia, and Calisaya Schuhkraft, will be concluded in 1880. The analyses 97 and 98 were carried out with a view to ascertain if such young officinalis trees had already an appreciable value. The result is assuring. The experiment was made by choosing ten trees of different exterior and origin in a plantation, cutting from each two strips, mixing them and analysing. The wounds were covered with moss, and in two months they were all covered with new bark. It was found by previous experiments that bark cut in quills was not injured by being dried in the sun. But the question was whether bark cut in shavings (scraped) could also bear the drying in sunlight without a decrease taking place in the yield of alkaloid and especially of quinine.

The analyses 23—28 and 90—91 were carried out to gain data for the answering of this question. The bark, cut from one stem, was divided into two equal parts and the one-half dried in the sun, the other over an oven. This experiment was tried three times with bark of different Ledgeriana trees and once with succirubra. The differences are on the whole so insignificant that there need be no fear of drying in the sun, even for these barks cut in the shavings. The cinchona cordifolia—No. 116—was analyzed in order to better determine the value of this kind. It belongs to the cinchonine producers, approaches in that respect to C. micrantha, from which, however, the variety differs greatly, and is of little value. This tree grows best in the lowest lying gardens at Lembang.

" In the analytical laboratory of the medical department, Weltevreden, by de Vrij's method so-called, out of 3,000 kilograms of dry bark 56 kilograms of quinetum were prepared—less than 50 per cent of the alkaloid that was present in bark. With this quinetum, trials will be made in the different military hospitals. Analyses were made of different kinds of quinetum, the result of which is given below. Of these analyses the second was performed by Mr. J. Hekmeijer, Principal of the analytical laboratory at Weltevreden.

Composition.	1	2	3	4
Insoluble in dilute hydrochloric acid	0·52	1·92	9 00	6·22
Water	4·30	0·80	6·00	3·80
Ash	3·00	0·80	2·20	2·10
Quinine	6·50	4·60	6·94	13·42
Cinchonidine	25·13	60·20	24·63	40·56
Cinchonine and quinomine	52 35	30·18	35 95	27·50
Amorphous alkaloid	7·12	0·42	9·92	4·80
Coloring matter and residuum	1·08	1·08	5·36	1·60

Quinetum No. 1 is that prepared in British India and sold by the Government there at 20 rupees per English pound. It is of a fine white colour, and has a peculiar sweet smell. It is packed in tin boxes holding ½ an

English pound, which are provided with directions for use in English and Hindustani. No. 2 was prepared at Weltevreden. It has the same appearance and smell as the Bengal, but is a little darker colored. No. 3 is a sample of the first quinetum prepared by Broughton in Madras and called by him amorphous quinine. It is a yellow stuff, sticky like resin, and looking like rhubarb powder,—on the whole a very impure preparation. Equally with the samples 1 and 4. I owe this also to the kindness of Dr. King, Superintendent of the Bengal cinchona gardens. No. 4 is quinetum of the manufacturer Whiffen in London. This had a gray-brown tint, smell of methyl-alcohol, and left a sandy residuum on solution in dilute hydrochloric acid. Besides these samples of quinetum another preparation was analyzed, produced by the same maker, under the name of quinetum sulphate. It has been tried in British India, and consists of

23·26	per cent	sulphate	of	quinine,
51·40	,,	,,	,,	cinchonidine,
24·30	,,	,,	,,	cinchonine,

This has a very good appearance and greatly resembles the quinine sulphate of commerce, but with the microscope the larger crystals of cinchona sulphate can be detected. This preparation is apparently combined mechanically by the mixture of $\frac{1}{2}$ cinchonidine sulphate with $\frac{1}{4}$ quinine sulphate and an equal quantity of cinchonine sulphate. The quinetum of different preparations was also of very different composition. As the loss is so excessively great in the preparation by extraction with dilute hydrochloric or sulphuric acid (de Vrij's method), that about half of the alkaloids are as good as lost in the process, another method of preparation is to be adopted in Bengal, and at the same time a large proportion of the quinetum will be made into sulphate compounds, with a view to remove the amorphous alkaloids, which sometimes form $\frac{1}{4}$ of the whole, and to which disagreeable results are ascribed."

Extract from letter to *Ceylon Observer*.

My oldest Ledgerianas will be five years old next month, and are well-grown, robust-looking trees, and many of them would give almost as much bark as a succirubra tree of the same age; for, though the stem may be smaller, the bark is far thicker. I measured four of the best to-day, growing side by side. They averaged 16 feet in height, and stem 13$\frac{3}{4}$ inches in circumference, a foot from the ground. Now to compare Ceylon with Java, Mr. Moens says that it takes four of his four year old Ledgerianas to give one kilogram of dry bark, *i. e., each tree gives just nine ounces.* This statement is not very clear, and I can hardly believe it to mean that if a tree were cut down *all* the bark would only weigh nine ounces. Perhaps it means that nine ounces can be taken from a living tree without killing it. I unfortunately have no four year old trees, but I am perfectly certain that at four years my trees would have averaged more than twice nine ounces, and one tree (one of the best) broken across by the wind last year (when it was four years) gave almost three lb. of dry bark, exclusive of the stump and root.

Mr. Moen's interesting figures about his fifty Ledgerianas, two years old, led me to compare mine.

To-day I most carefully measured 52 trees beginning at the first tree of the first line, passing over only two, one with a double stem, and one that

had been broken across ; the other 50 were a fair average and included two small supplies. If my calculations of the Java metre is correct the Java and Ceylon figures are :—

	Fifty Java 2 years old Ledgerianas,	Fifty St. Andrews $22\frac{1}{2}$ months old Ledgeriana,
Average height	57	65 inches.
,, stem circumference 4 inches from ground	3·937	3·965 ,,
,, across branches	39·37	38 ,,
Maximum height	74·80	84 ,,
,, stem circumference	5·51	5·5 ,,
,, across branches	55·12	48 ,,

Mr. Moens describes his measurements as being from two year old trees in a "flourishing garden at Tjibeureum" ; mine are from trees planted out on 5th July 1879 amongst coffee. So, taking all these circumstances into consideration, the Ceylon figures are so much better than the Java ones that I cannot help thinking that Mr. Moens dates his four or two years from the day the seedlings are picked out, and not as we do in Ceylon from the day the plant is put out in the open. If Mr. Moens continues to record the growth of his 50 trees, I will be much interested to continue the comparison.

My old trees are planted at an elevation of about 4,000 feet. The 50 recorded above are growing on steep land, with deep gritty soil at an elevation of about 4,250 feet. I believe that the non-clayey slopes of the hills in the centre valleys of Dimbula, Dikoya, and Maskeliya, will grow Ledgeriana perfectly, and that with a sheltered eastern aspect, it will do well up to 5,000 feet, although I would prefer 3,500 or so.

I send you a small bit of bark from one of my old trees ; in similar bark I have *seen* the alkaloids and it gives an analysis of 4·79 sulphate quinine at four years of age—probably the richest Ceylon bark, of its age, upon record. If you break the piece of bark, examine the fracture under a microscope, I dare say you will see the particles.

I see that Mr. Moens, as well as Dr. Trimen, remarks upon the difficulty of getting "cuttings" to strike. I hardly know what the technical meaning of a "cutting" is. Does it include *suckers* from the stem of the tree? I have no difficulty whatever in getting suckers to strike, but with the ends of branches it is very different, and only two or three per cent root.—Yours truly,

THOS. NORTH CHRISTIE.

A Dimbula planter writes :—"I was most anxious to compare the analysis of Mr. Moens' two year old shoots of original Ledgeriana, with an analysis Mr. David Howard had kindly made for me of six thirteen month old Ledgerianas from Conon estate. I cut these six trees down and sent home the whole of the stem bark. The best analysis was No. VI, viz :—2·1% sulphate quinine. The average of the whole six was 1·3%. As Mr. Moens' analysis No. 48 is of two year old shoots, of old trees and is only 2·86% sulphate quinine, I think there is no doubt that Ceylon will be able to grow as good Ledgeriana bark as Java, by analysis, and Mr. Christie has shewn that we can also compete with them in growth."

"CINCHONA PLANTERS' MANUAL."

Errata.

Page I.—Lines 29 and 30, for "which all consist of" read "which consist of all or some of the elements."

Page II.—Line 34, for "then cinchonidine; quinidine and cinchonine" read "then quinidine; cinchonidine and cinchonine."

Page 15.—Line 35, for "C. H_{24}, N^2 O_2," read "C_{20} H_{24}, N_2, O_2."

Page 17.—Line 37, omit "officinalis."

Do 22.—Line 11, for "officinalis" read "officinales."

Do 25.—Line 2, for "Cuco" read "Cusco."

Do 27.—Line 37, for "tomentose, pubescent" read "tomentose or pubescent."

Do do.—Line 38, dele "——" after "fruit."

Do 28.—Line 7, after "here" insert "or to the next species."

Do 36.—Line 34, for "15,000 lb." read "1,500 lb."

Do 54.—Line 16, for "500" read "5,000"

Do 99.—Line 20, for "1 lb. of guano" read "¾ lb. ammonic sulphate."

Do do.—Line 22, for "¾ lb. ammonic sulphate" read "1 lb. of guano."

Do 111.—Line 7, for "sulphate" read "alkaloid."

Do 113.—Line 11, for "quinine" read "sulphate of quinine."

"CINCHONA PLANTERS' MANUAL."*

(From the *Ceylon Observer*, Aug. 5, 1881.)

(COMMUNICATED).

This book will be found to be very useful to all engaged in the cultivation of this valuable tree. It is a handy volume of over 200 pages demy octavo containing the cream of information known regarding cinchona.

As in most works so in this a few errors have crept in. On p. 1 it is said "all alkaloids consist of carbon, hydrogen, oxygen, nitrogen alone." This is not the case, for there are a large number of alkaloids which contain no oxygen, *e.g.* nicotine from tobacco, conine from hemlock, &c. On p. 4 "The stem (endogenous) is enlarged." This must refer to the height and not diameter. A little further on we are told "reproduction does not commence till the plant is provided with a store of accumulated food"; this is somewhat at variance with the statement on p.78, for, when a tree has reached a sufficient size and becomes impoverished, it generally makes an attempt to reproduce its kind. In the second chapter, on p. 11, it says :—"warmth of climate accelerates changes and hence bark grown at low elevations contains less quinine," but the next statement "it follows that the quicker the plant grows," &c. is somewhat awkward, for warmth generally accelerates growth and cinchona thrives very well at sea level. A very fine specimen was growing a very short time ago in the Cinnamon Gardens, of no great age, about five or six years, was over 20 feet high, with a girth of more than three feet. Although this tree was quickly grown, the quinine was slight. It is tolerably rich in alkaloids but they are in an uncrystallizable condition. Nevertheless it would make fine druggist's bark.

On the same page the value of quinidine ought to be placed before cinchonidine.

A little further on "the act of flowering does not appear to have any direct influence on the amount

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* The Cinchona Planter's Manual, by T. C. Owen. Colombo: A. M. & J. Ferguson. 1881.

of alkaloid in the bark" requires verification. In several plants *e.g.* tobacco, the flowering has an effect on the alkaloids secreted.

The formula for quinine on p. 15 is a misprint. The error is cleared up in the explanation following on p. 28. "It (Ledgeriana) is greatly given to sporting but always within certain limits" reminds one of the wonderful sporting on a Maskeliya estate, so much so that the plants have been pushed out of the category Ledgeriana. They are, however, good percentage quinine yielders, which is the great point to look after.

Chapter III. deals with soil, &c. On p. 45-51, 61, certain statements are made regarding the suitability of soil which generally hold good, but it might be noted that in some parts of Ceylon cinchona trees thrive in stiff clay soil near a swamp and give a good proportion of quinine.

The analyses on p. 47 need not have contained the item "Sulphuric acid, carbonic acid, and chlorine not determined," for they must have been absent, as the other constituents make up the 100 parts.

On p. 50, reference is made to "phosphoric acid not being so high as in soil formed from sedimentary geological formations." It must be remembered that our chief formation is but a metamorphosed sedimentary one, and metamorphic action would not destroy phosphoric acid.

With regard to the chapters on weeding, roads, draining, planting, nurseries, they are based on experience, and will hold good generally. Part IV. deals with *manuring*. On this there is much to be learnt, as very few experiments have been tried and the bark tested by analysis. More information on this is very desirable.

Messrs. Rucker and Bencraft's unit value of 1/9 or 1/9½ is too high except for high percentages. Allowance must be made for manufacturer's charges.

It would be interesting to know why the outer cells of the bark, as stated on p. 28, and 112, are richer in quinine, which is correct, but this does not agree with the order of the formation of the alkaloids given on p. 11. First uncrystallizable quinine; next crystallizable quinine to cinchonidine to cinchonine.

Mr. Karslake's process will no doubt be found to be exceedingly good. It is a capital way of punishing a tree and at the same subjecting it to a minimum of harm. Quinine and its partners are stored

up in the bark, and by punishing a tree in this way its energy is then diverted to making good the loss of that which has been or is *about to be* (in Mr. Karslake's process) taken away.

The great changes to which bark is subjected, pointed out on p. 141, should be a sufficient inducement to establish a local manufactory here, and ship home either the *crude* alkaloids or the pure, which could be done for a moderate outlay and would prove remunerative. The latter part of the first paragraph (p. 165) is somewhat complex. Are we to gather from this that, when a tree is dying from ringing or other causes, the alkaloids are actually drawn up to the leaves, and that disorganization of tissue below prevents its return? Although it may be regarded as a *fallacy* that checking a tree increases the richness of the bark, yet there is every reason to believe that, checking, by stripping, shaving, or Mr. Karslake's process does make it richer, and there is also evidence to show that other modes of reasonable injury serve the same purpose.

Dr. Trimen's chapter on the characters of the different species will be a great guide to those who wish to follow up the outward characters of the various kinds. A little information might have been given on the dry bark characters, as far as is known. On p. 188 appendix, regarding the analyses A. and B., the salts of the alkaloids should not be added to the cinchonine alkaloid and then called total. The total alkaloids in A. and B. would be much less than the quantity stated.

Mr. Owen deserves great credit for this work, and we trust that a second edition will soon be required. It is a book which ought to be in the hands of every planter, of cinchona as well as of those interested in quinine.

THE CINCHONA PLANTERS' MANUAL.

(From the Ceylon Observer, August 11, 1881.)

Mr. Owen writes, with reference to a correspondent's criticism of the Manual, as follows :—

"I have to thank your correspondent in the *Observer* of the 5th instant, for his notice of the 'Cinchona Planters' Manual,' but hope I may be allowed to reply to one or two of his remarks. I am sorry the paragraph on the formation of the alkaloids is not clear to your correspondent, but I cannot help thinking the meaning is plain. The effect of the warmth at low elevations is to cause the higher alkaloids to change into the lower ; it also causes the tree to grow quicker and secrete the more valuable alkaloids (which are just formed) more rapidly : hence the former effect is modified by the latter. Allusion is distinctly made to 'the accelerated growth at low elevations.' As to the influence of flowering on the alkaloids in the bark, the only authority on the subject is Mr. Broughton whose words I quote, and he adds in his report of December 9th, 1869, that this is 'a point on which I have made a careful enquiry.'

"In the formula for quinine on page 15, two numerals have dropped, but the printer's error is made plain in the next few lines.

"I cannot understand cinchona 'thriving in a stiff clay soil near a swamp.' As far as our knowledge and experience go the trees invariably die off at an early age in such situations.—The analyses and remarks on pages 47-50 are by Mr. Hughes. His item 'sulphuric acid, carboinc acid, and chlorine not determined' must have had some meaning, though on the face of it, it seems superfluous.

"Messrs. Rucker & Bencraft's unit value of 1/9 and 1/9½ was correct at the time it was written and quoted, and is borne out by the sale list immediately preceding.

"The order of formation of the alkaloids as decided by Mr. Broughton is not necessarily at variance with the fact of the outer cells of the bark being the richest in quinine, for in this part such changes as take place are slow and probably consist merely of a storage of alkaloid, the *younger tissues* being the scene of the changes described by Mr. Broughton (*vide* pages 45 and 46 of the previously mentioned report).

"The disappearance of the alkaloids from the bark of a dying tree is a fact difficult of explanation, and apparently antagonistic to the theory that checking the growth of the tree increases the secretion of the alkaloids, in support of which theory there does not appear to be any evidence which is not capable of explanation on other grounds."

ANALYSIS

OF

CINCHONA BARK

FOR

ALKALOIDS.

THE 1,000 GRAIN TESTS.

(1) Determination of Moisture and Quinine in form of White Crystalline Sulphate.

(2) Determination of Moisture, total Alkaloids, and Quinine in form of White Crystalline Sulphate.

(3) Full Analysis.

NOTE.—The separation of quinine in form of white crystalline sulphate is the only certain test of value to the manufacturer. Not less than 1,200 grains bark should be sent; 2,400 admits of second determination, sometimes desirable.

300 grain tests can be given (but are not recommended), quinine being determined and crystalline sulphate calculated.

M. COCHRAN, M. A., F. C. S.

COLOMBO, *22nd July, 1881.*

SEND TO DIXON TO ANALYSE CINCHONA BARK.